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# JOURNAL OF THE UNITED STATES ARTILLERY

PUBLISHED UNDER SUPERVISION OF THE SCHOOL BOARD
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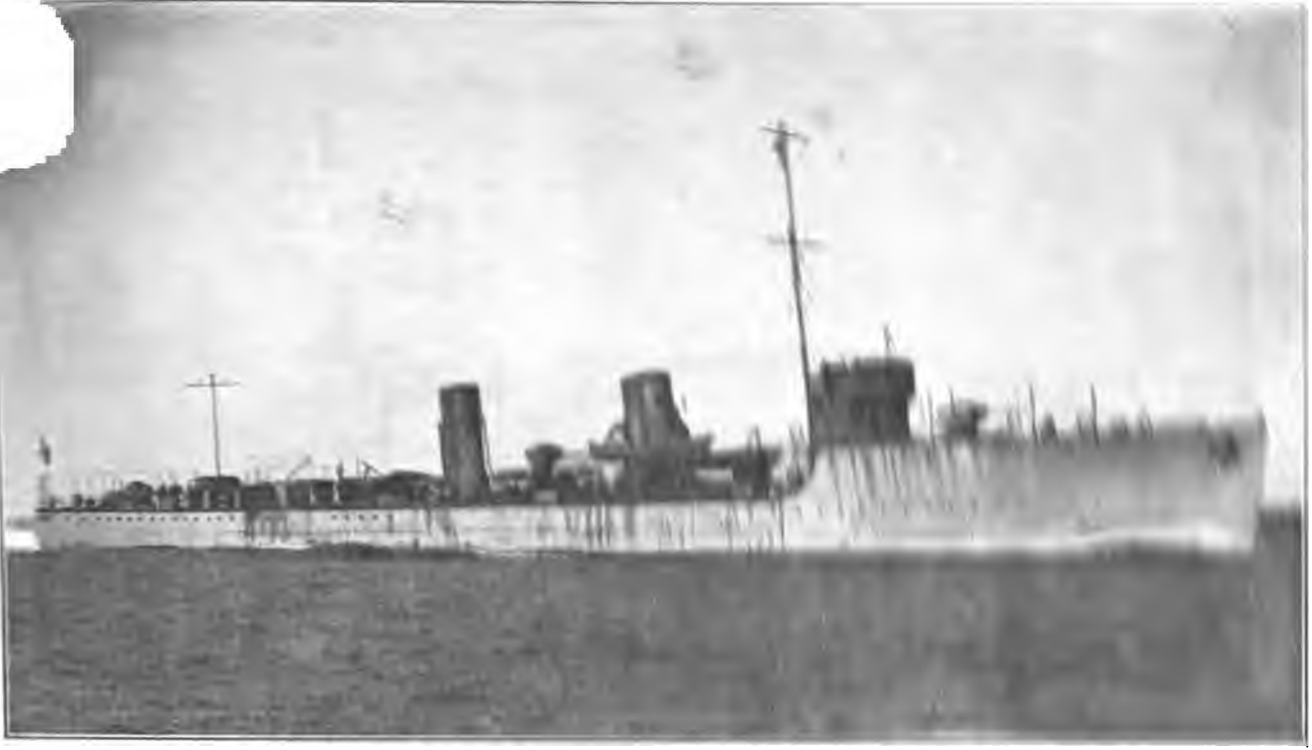
# ERRATA

Page 20, next to the last equation on page: for sin $2'\varphi$ read sin $2\varphi'$.

Page 57, third column, last entry: for 13 read 10.

Page 64, entry in log $C'$ column opposite 300 in $Z$ column: for 4.7676 read 4.7576.



*Photograph by Stephen Cribb, Southsea.* [illegible]

British Destroyer "Laforey" (L Class)

Displacement, 807 tons. Armament: three 4-inch, four 21-inch tubes (in pairs). Designed H.P. [illegible]
Dimensions: 260 x 27½ x 8½ feet. *Jane.*

JOURNAL

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# NOTES ON DIRECT FIRE

BY 1ST LIEUTENANT GEORGE A. WILDRICK, COAST ARTILLERY CORPS

For two or three years past there has seemed to be a need for an article on direct fire, both because of new methods of application of ballistic data and because of works hitherto in use being out of print. This article treats only of the problems most likely to be encountered at the battery: for a thorough study of the subject, there are suggested the following standard works, from which the present writer has freely borrowed:

*Artillery Circulars N*, Exterior Ballistics, and *M*, Ballistic Tables, by Col. James M. Ingalls, U.S.A., retired.

*Ballistics*, Part I, by Major Alston Hamilton, Coast Artillery Corps.

*Notes on Ballistics*, by Major Alston Hamilton, Coast Artillery Corps, JOURNAL OF THE U. S. ARTILLERY, Nov.-Dec., 1909.

*Manual for Coast Artillery*, Part I, Gunnery, D. R. C. A., 1905.

*Exterior Ballistics*, by Major Edward P. O'Hern, Ordnance Department.

For high angle fire, see *Notes on Ballistics*, by Major Alston Hamilton, C. A. C., published in the JOURNAL OF THE U. S. ARTILLERY, Sept.-Oct., 1913.

The writer desires to acknowledge his indebtedness to Major J. M. Williams, C. A. C., Major George A. Nugent, C. A. C., and Capt. A. L. Rhoades, C. A. C., for encouragement and advice.

The following notations are used herein:

| Symbol | Expression for | Expressed in |
|---|---|---|
| $j$ | Jump. | Degrees, minutes, and tenths of a minute. |
| $V$ | Muzzle velocity | Feet per second. |
| $v$ | Remaining velocity. | Feet per second. |
| $v_\omega$ | Velocity at point of fall. | Feet per second. |
| $\varphi$ | Range table angle of departure. | Degrees, minutes, and tenths of a minute. |
| $\varphi_x$ | Quadrant angle of departure. | Degrees, minutes, and tenths of a minute. |
| $\varphi_\epsilon$ | $\varphi$ corrected for $\epsilon$ | Degrees, minutes, and tenths of a minute. |
| $\varphi_1$ | Quadrant angle of elevation. | Degrees, minutes, and tenths of a minute. |
| $'$ | Denoting a nontabular value. | Thus, if we know $\varphi$ for a 2250-f.s. gun and a range of 7000 yds., we denote by $\varphi'$ the angle of departure when the M.V. is reduced to, say, 2200 f.s. |
| $\theta$ | Inclination of trajectory to horizontal at any point. | Degrees, minutes, and tenths of a minute. |
| $\omega$ | Angle of fall. (Sometimes expressed in terms of slope, as 1 on $n$.) | Degrees, minutes, and tenths of a minute. |
| $w$ | Weight. | Pounds. |
| $m$ | Mass. | Pounds; $M = \frac{w}{g}$. |
| $g$ | Acceleration due to gravity. | Feet per second; 32.16 is assumed as the standard. |
| $r$ | Retardation. | Feet per second per second. |
| $p$ | Resistance. | Pounds. |
| $t$ | Elapsed time after gun is fired. | Seconds. |
| $T$ | Time of flight. | Seconds. |
| $W$ | Wind velocity. | Miles per hour. |
| $W_x$ | Range component of wind velocity; plus for rear and minus for head wind. | Miles per hour. (In some computations, as in deduction of wind factor, wind is expressed in feet per second as $W = \frac{44}{30} W_x$.) |

| Symbol | Expression for | Expressed in |
|---|---|---|
| $d$ | Diameter of bore or caliber of projectile. | Inches. |
| $n$ | Radius of ogive. | Calibers. |
| $\epsilon$ | Depression angle due to height of site and curvature. | Degrees, minutes, and tenths of a minute. |
| $R$ | Horizontal range. | Yards. |
| $X$ | Horizontal range. | Feet. |
| $C$ | Ballistic coefficient under range-table conditions. | |
| $C_1$ | Ballistic coefficient under non-range-table conditions. | |
| $c$ | Coefficient of form. | |
| $\delta_1$ | Standard atmospheric density. | |
| $\delta$ | Actual atmospheric density. | |
| $f_a$ | Altitude factor. | Takes into account decrease in density of air as projectile rises. |
| $f_w$ | Wind factor. | Takes into account increased wind effect on projectile as it rises. |
| $\gamma$ | Reducing factor. | Takes into account oblique presentation of projectile to the resistance of the air. |
| $y_0$ | Maximum ordinate of trajectory. | Feet. |
| $i$ | Characteristic index. | |

## THE GUN

The following is quoted from *Gunnery*, of D.R.C.A., 1905:

> A *Gun* is a machine by means of which the force of expanding powder gas is utilized for the purpose of propelling a projectile in a definite direction. It consists essentially of a metal tube, closed at one end, of sufficient strength to resist the pressure of the gases, in which is placed a projectile designed to move through the tube. The force of the expanding gases propels the projectile through this tube causing it to start in its trajectory in a definite direction.
>
> The explosion of the powder gives rise, by its decomposition, to a large amount of gas, which tends to expand in all directions and to occupy a space much greater than that in which the powder was contained, and consequently exerts pressure in every direction.
>
> The energy utilized in developing the force which propels the projectile is heat and the heat carrier is gaseous, therefore a gun is the simplest form

of gas engine. The expansion of gases which develops the force that drives the projectile is entirely due to heat, for a gas at absolute zero temperature would have no tendency to expand.

The direction in which the projectile leaves the muzzle, is determined by the pointing of the gun. For any particular gun the initial velocity with which the projectile starts in its path through the air is determined by the kind, weight, and condition of the powder used, the shape and dimensions of the powder grains, the density of loading, and the weight of the projectile.

The force of the powder gas acts upon the projectile while it is in the bore and for a short distance after it leaves the muzzle, that is while it is in the powder blast. It is therefore manifest that a large amount of this force is wasted, in consequence of the practical limitation in the length which can be given to a gun. Experiments have shown that only abobut 1/8 of the total energy of the expanding gases is ever utilized in a gun of ordinary dimensions; this portion is termed *the total work in the gun.*

A portion of this work is lost in heating the gun, and this loss of heat reduces the amount available to produce expansion.

*The total work in the gun* is expended as follows:

In heating the gun.
In expanding the walls of the gun.
In driving the products of combustion through the bore, and in driving out the column of air in front of the projectile.
In deforming the rotating band and in overcoming friction in the bore.
In giving rotation to the projectile.
In accelerating the projectile, that is gradually increasing its velocity.

As the prime object is to give acceleration to the projectile, it is important to know how much of "the total work in the gun" can be utilized for this purpose. Experiments have shown that between 80% and 90% of "the total work in the gun" is employed in accelerating the projectile.

If a charge of powder is burning in a rigid space, that is one that has a fixed capacity, the expansive force of the gas will at any instant depend upon the amount of gas which has been formed and its mean temperature. As the amount of gas or its temperature increases, the expansive force will increase. If now at any instant the space in which the powder is burning be increased, the other conditions remaining the same, the expansive force will decrease. In a gun the space in which the powder is burning has a fixed capacity until the shot starts, after which the space increases.

The pressure on the walls of the gun and on the base of the projectile at any instant depends upon the expansive force of the gas at that instant. As long as the increase of expansive force, due to an increase of the amount of powder burned or to temperature, is greater than the decrease of expansive force due to an increase in the space it occupies, the pressure on the walls of the gun and base of the projectile is increasing. When the decrease due to the increase in the space, is greater than the increase due to the amount of powder burned or to temperature, the pressure falls off.

This is what happens in a gun; the pressure increases up to a certain amount and then begins to fall off. The greatest pressure is called the "maximum pressure" and this is the pressure indicated by the pressure gauge. This pressure must not exceed that which it is considered safe to use in the gun.

The form and size of the grain should be so regulated as to produce the greatest possible muzzle velocity with a maximum pressure not exceeding that which is allowed for the gun.

It is sufficient to say here that within certain limits the larger the grain the less will be the initial burning surface per pound of powder, and the less will be the maximum pressure produced for a given charge of powder. This will admit of using a larger charge of powder which will, as a rule, give a greater muzzle velocity. As the size of grain is increased the percentage of the grain which will be consumed while the projectile is in the bore is decreased, leaving a certain portion of each grain unburned when the projectile leaves the muzzle. We will finally reach a point at which the weight of the unburned powder will equal the additional amount of powder which has been put in the chamber and of course no further increase of velocity can be obtained and if we continue to increase the size of grain without increasing the charge, the velocity will fall off. From which it is manifest that for each class of gun there is a limit to the size of grain which must not be exceeded. There is also a limit in the opposite direction and it is possible to produce dangerous pressures in a gun by even a small charge of powder the grain of which is too small for the gun.

For this reason a powder should not be used in a gun for which it is not designed. If circumstances make it absolutely necessary to do so, use a powder having a grain which is larger than the normal for the gun.

The maximum pressure and the muzzle velocity are also affected by the density of loading; it is important therefore that the projectile should always be seated so that its base will be at the same distance from the face of the breech, in order to insure obtaining uniform muzzle velocities.

The uniformity of action of the powder is also greatly dependent upon the *ignition and inflammation* of the charge. By *ignition* is meant setting fire to the charge, and by *inflammation* the spread of the flame from grain to grain, over the surface and into the perforations of the several grains. It is desirable to produce as nearly a simultaneous ignition of the entire charge as possible, in order to eliminate the variation in the rate of emission of gas, due to an irregular spread of the inflammation from grain to grain.

Black powder ignites very readily, but smokeless powder requires a larger amount of flame to insure instantaneous ingition; for this reason an igniting charge of black powder is attached to each section of a cartridge of smokeless powder.

An extremely hard or very smooth grain is difficult to ignite. A charge composed of large grains inflames more readily than one composed of small grains, in consequence of the size of the interstices. A grain with large perforations inflames more readily than one with small perforations. With multiperforated grains, the longer the grain the slower will be the inflammation with the same sized perforations.

It has been ascertained by experiment that, if a cartridge is much shorter than the powder chamber, there is a liability to produce a motion of or in the gas formed in the chamber, which materially increases the maximum pressure on the breech. This motion has been generally considered to be a "Wave Motion."

An extremely long chamber renders simultaneous ignition and inflammation difficult and tends to produce so-called "wave motions." Hence, in order to contain the required amount of powder without giving it undue length, the chamber is given a greater diameter than the main bore.

The rate of emission of gas from a burning grain is dependent upon its rate of burning and the area of the burning surface. The rate of burning increases with the pressure, and also probably with the temperature of the inflamed gases.

As a rule the larger the grain the less will be the area of burning surface per pound of powder, and the slower will be the rate of emission of gas for the same rate of burning, for any given charge.

Whatever may be the form of a grain there is always one dimension that when burned through, the entire grain is consumed. Thus with two tubular grains of the same length, one of them ½ inch in diameter and the other 1 inch in diameter, both having the same thickness of wall, say 1/8 of an inch, it is manifest that as soon as the wall is burned through both grains are consumed. The larger of these grains would weigh about twice as much as the other, and twice the amount of gas would be evolved. This dimension is called "the least dimension" of the grain, and sometimes the "critical dimension" of the grain. In a multi-perforated grain the critical dimension is the thickness of the web between the perforations.

For similar guns the "critical dimension" of the grain must be proportional to the caliber of the gun.

When a grain is said to be too large or too small for a gun, too quick or too slow for a gun, it is the "critical dimension" which is spoken of.

Uniformity in the size, shape, density, surface smoothness, and toughness of the grain is essential in order to obtain uniform results.

* * * * * * * * * * * *

In making up cartridges care should be taken that the bags are of the same dimensions, especially as to length. The length of the cartridge should not be less than nine-tenths of the length of the chamber.

## THE TRAJECTORY

In order to reduce confusion of ideas to a minimum, in this article the several elements of the trajectory are stated to be as follows:

*Trajectory.*—The curve described by the center of gravity of the projectile in passing from the muzzle of the gun to the point of impact.

*Angle of departure.*—The inclination of the line of departure to the line of shot.

*Line of shot.*—The line from the trunnions to the point of impact.

(See Fig. 1.) $I'$ is the point of impact when the point of impact is in the horizontal plane containing the axis of the trunnions, sometimes called the initial plane. The value described as the *angle of departure* in the range tables, and referred to herein as $\varphi$, is represented by the angle $AG'I'$. As the gun is raised above the water level (the reference surface in coast artillery work) the point of impact lies in a plane below the initial plane, at a point $I$. The line of shot now has a depression represented by the angle $I'G'I$, and, in order to compensate for the change in the height of site, the piece should be depressed by the same angular amount, *I'G'I* = *AG'B*. In other words the angle of departure is kept sensibly constant, or *AG'I'* = *BG'I*, if the principle of the rigidity of the trajectory be accepted.

The principle of the rigidity of the trajectory assumes that the trajectory preserves the same form, whether the chord be horizontal, as *G'I'*, or inclined like *G'I*. This is slightly erroneous, and its acceptance would cause the projectile to range beyond *I'*, if the latter point were projected vertically to the plane *GI*, notwithstanding the fact that the measured range *GI*, for which the piece would be laid, is slightly less than *G'I'*.*

In order that the projectile may not range too far, the quadrant angle of departure $\varphi_x$ must be slightly less than $\varphi_\epsilon$; that is, the correction to be applied to the range table angle of departure $\varphi$, in order to secure the quadrant angle of departure $\varphi_x$, must be slightly greater than $\epsilon$. This constitutes the essential difference between the values $\varphi_x$ and $\varphi_\epsilon$.

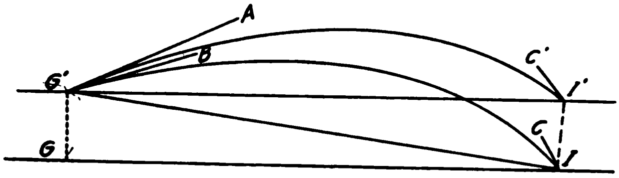

Fig. 1.

If *I'* be projected vertically to the plane *GI*, the angle *IG'I'* so formed would represent the value $\epsilon$.

*Quadrant angle of departure.*—The angle *BG'I'*, or the inclination of the line of departure to the horizontal.

*Line of departure.*—The tangent to the trajectory at the muzzle, or the prolongation of the axis of the bore at the instant the projectile leaves the muzzle.

*Angle of position* (or *depression*).—The inclination of the line of shot to the horizontal plane through the axis of the trunnions. It is designated by $\epsilon$.

*Pintle center.*—The vertical axis about which the carriage revolves.

*Range.*—The horizontal distance from the pintle center to the point of impact; in Fig. I, the distance *GI*. When the range is expressed in feet, it is designated by $X$; when in yards, by $R$.

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* See page 14, *Ballistics*, Part II, Major Alston Hamilton.

*Muzzle velocity.*—The velocity in feet per second with which the projectile leaves the muzzle in the direction represented by the line of departure. Due to the action of gravity, the projectile falls away from the line of departure.

*Angle of fall.*—The inclination of the tangent to the trajectory (at the point of impact) to the horizontal. The angle $C'I'G'$ ($\omega$) represents the value given in the range table in degrees and minutes, or as a slope of fall. Under the service condition, the angle of fall is represented by the angle $CIG = \omega + \epsilon$, and is represented herein as $\omega_\epsilon$.

*Ballistic coefficient.*—The ballistic efficiency of the projectile, or its power to overcome the resistance of the atmosphere and retain its horizontal component of velocity. It depends for its value on:

(1) The ratio of the weight to the cross-sectional area; that is, the "sectional density" represented by the ratio $\frac{w}{d^2}$. In other words, the heavier the projectile per unit of area exposed to resistance, the more efficient will it be in retaining its velocity.

(2) The shape of the point. It is obvious that sharpening the point will reduce the resistance encountered, will reduce the retardation, and will permit the projectile to retain its velocity the better. The value of sharpening the point varies with velocities, for a sharp point will obviously confer more advantage at 2000 feet per second than at 2 feet per second.

(3) The oblique presentation of the projectile to the atmosphere. The gyroscopic action of the rotating projectile causes the point to precess so as to describe a small circle about the tangent to the trajectory. The projectile is therefore never exactly head-on to the resistance of the air; but, due to the small curvature of direct fire trajectories, the precession probably never describes more than the first quarter of the circle referred to above, so that the point is slightly above and to the right of the tangent to the trajectory. This causes the projectile to be obliquely presented to the air and consequently to drift to the right. It can also be observed that the projectile will tend to "kite."

The factor $i$ is called the characteristic index of the projectile; it is determined experimentally; it embraces the variation in retardation along the trajectory noted under (2) and (3); and it is placed in the equation to credit a projectile (having a given sectional density) with a ballistic coefficient equivalent to the ballistic coefficient of the projectiles used in the firings on which Tables I and II are based, and takes the place of the expression $\frac{\beta c}{f_a}$ long used in our service.

The leading thought at present is to place the equation for the ballistic coefficient in the following form:

$$C = \frac{w}{id^2}$$

(See range tables for long pointed projectiles.)

For the above expression, the wind is assumed to be zero along the range, and the atmosphere normal with 78% saturation with moisture, the average saturation along the Gulf and Atlantic coasts.

It is obvious that the ballistic efficiency of the projectile will vary accordingly as there is a head or rear wind component, and with variations of atmospheric density. Therefore, while

$$C = \frac{w}{id^2}$$

represents the equation for the ballistic coefficient under range table conditions, the general expression is

$$C = f_w \cdot \frac{\delta_1}{\delta} \cdot \frac{w}{id^2}$$

The values of $i$ for the purposes indicated above have been determined for the computation of range tables for long pointed projectiles, as follows:

For 5-inch and 6-inch guns.................$i$ = .61

For 8-inch, 10-inch, 12-inch, and 14-inch.....$i$ = .63

For projectiles having a general design similar to those used in making the firings on which our ballistic tables are based (shot and shell for seacoast guns), $i$ is a constant; for other types of projectiles (shot and shell for land guns, and shrapnel) $i$ is usually not constant, and is determined as a function of the range by experimental firing.

Existing range tables for capped projectiles were constructed on the value of the ballistic coefficient expressed as follows:

$$C = f_a \cdot \frac{w}{\gamma c d^2}$$

The general expression became

$$C = f_a \cdot \frac{w}{\gamma c d^2} \cdot \frac{\delta_1}{\delta} \cdot f_w$$

The following discussion of what the ballistic coefficient really is, is taken from *Exterior Ballistics* (O'Hern).

4. *Determination of the resistance of the air.*—The relation between the velocity of a projectile and the resistance opposed to its motion by the air has been the subject of numerous experiments. The usual method has been to determine the loss of velocity over a known path. By equating the corresponding loss of energy with the product of the resistance times the path the value of the resistance has been determined.

Thus let

$w$ = weight of projectile in lbs.
$m$ = mass of projectile = $w/g$.
$d$ = diameter of projectile in inches.
$v_1$ = velocity of projectile at beginning of measured path.
$v_2$ = velocity of projectile at end of measured path.
$s$ = distance in feet between points of measurement of $v_1$ and $v_2$.
$\rho$ = resistance of air in lbs.
$R^* = \frac{\rho g}{w}$ = retardation due to air resistance.

Then

$$\rho s = \frac{mv_1^2}{2} - \frac{mv_2^2}{2} \tag{1}$$

Whence

$$R^* = (v_1^2 - v_2^2)/2s \tag{2}$$

In order that the computed values of $R^*$ may be accurate the distance $s$ must be so short that $\rho$ may be considered as uniform over that path.

Early investigators, such as Robins in 1742 and Hutton in 1790, determined the values of $v_1$ and $v_2$ by means of a ballistic pendulum placed at varying distances from the gun. Later investigators have used electro-ballistic instruments, the improvements in which have steadily increased the accuracy of the determinations. The latest forms of instruments and methods of measuring velocities are described on pages 32-40, Lissak's *Ordnance and Gunnery*. Much data has been secured concerning various projectiles under various atmospheric and other conditions. How these results have been standardized and made applicable to other projectiles and other atmospheric conditions will be explained in the discussion of the so-called Ballistic Coefficient.

5. *Mayevski's formulas for the resistance of the air.*—The values used in our present ballistic tables were derived by General Mayevski from Krupp firings made at Meppen about 1881. In expressing the relation between the resistance of the air and the velocity of the projectile, General Mayevski assumed that the resistance encountered by a given projectile under given atmospheric conditions varied as some power of the velocity, the law of retardation being expressed by the equation

$$R^* = \frac{A_n v^n}{C} \tag{3}$$

In which $R$ = retardation to be determined experimentally as per equation (2).

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* Represented by $r$ by Ingalls and elsewhere in this article.—*G. A. W.*

$C$ = ballistic coefficient varying inversely as the retardation. An equation from which $C$ can be calculated will be given later.
$n$ = some power of the velocity.
$A_n$ = a corresponding constant, $n$ and $A_n$ to be determined from equation (3) after substituting the values of $v$, $R$, and $C$.

The following values of $A_n$ and $n$ were thus determined by Mayevski and by Zaboudski.

| Velocities, f.s. | $n$ | log $A$ | Velocities, f.s. | $n$ | log $A$ |
|---|---|---|---|---|---|
| Below 790 | 2 | 5.66989-10 | 1370 to 1800 | 2 | 6.11926-10 |
| 790 to 970 | 3 | 2.77344-10 | 1800 to 2600 | 1.7 | 7.09620-10 |
| 970 to 1230 | 5 | 6.80187-20 | above 2600 | 1.55 | 7.60905-10 |
| 1230 to 1370 | 3 | 2.98090-10 | | | |

It will be noted that the values of the log $A_n$ taken in connection with the corresponding values of $v^n$ are such as to make the values of $R$ plotted as a function of $v$ form practically a smooth curve.

More recent firings by the Gâvre Commission in France have shown that the above values of $A_n$ and $n$ are not strictly accurate but no ballistic tables of greater accuracy have yet been computed. It now appears that the law of the air resistance is intimately connected with the velocity of sound and that Newton's Law of the Square, is in the main true.

6. *The Ballistic Coefficient.*—In Mayevski's expression for $R$*, equation (3), he assumed

$$C = \frac{\delta_1}{\delta} \frac{w}{cd^2} \tag{4}$$

In which

$\delta_1$ = standard density of air, that is with barometer 760 *mm.*, thermometer 15°*C*, relative humidity ½.
$\delta$ = density of atmosphere at time of experiment.
$c$ = coefficient of form. A general expression for its value will be deduced later.
$w$ = weight of projectile in lbs.
$d$ = diameter of projectile in inches.

The value of $\delta_1/\delta$ for any weather conditions may be obtained from Table A, of this pamphlet, or from Table VI of *Artillery Circular M*, with the barometer and the thermometer readings as arguments.

It is evident from equation (3) that $A_n v^n$ is directly equal to $R$ only when $C = 1$. That is, the tabulated values of $A_n v^n$ and their derived functions are based on the retardation encountered by a projectile of one pound weight, since $w = 1$; of one inch diameter, since $d = 1$; of standard form, since $c = 1$; moving in an atmosphere of standard density, since $\delta_1/\delta = 1$. It then becomes evident that $C$ is the factor by means of which the values of $A_n v^n$ are made applicable to projectiles and atmospheric conditions which differ from these standards. A thorough understanding of $C$ is of such fundamental importance that the meaning and use of the factors already appearing and certain others to be introduced later will now be fully considered. It will be noted that $C$ varies inversely as the retardation and hence measures the ability of the projectile to maintain its velocity. Since the weight of air to be displaced by a projectile per unit of travel will vary directly as the density of the air and as the area of cross-section of the projectile, the retardation will vary directly as these factors. We accordingly find $\delta/\delta_1$ and $d^2$ as inverse factors in the expression for $C$. Every factor but $d^2$ has disappeared from the ratio of the areas, $\pi d_1^2/\pi d^2$, because the diameter of the standard projectile $d_1$, was assumed as one inch.

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* Represented by $r$ by Ingalls and elsewhere in this article.—*G. A. W.*

Since the retardation of a projectile acted upon by a given force will vary inversely as the weight of the projectile, $w$ will enter as a direct factor in the expression for $C$.

The factor $c$, called the coefficient of form, is habitually determined by experiment.

The following formula gives its value for an ogival head

$$c = \frac{2k}{n}\sqrt{\frac{4n-1}{7}} \tag{5}$$

In which

$n$ = radius of ogive in calibers.

$k$ = a constant which is ordinarily unity, but which is determined experimentally and thus compensates for peculiarities of conformation not attributable to the radius of the ogive. For $k = 1$ and $n = 2$, the value in general use in the U. S. Service, $c = 1$.

So when we say that under a given set of atmospheric conditions a certain projectile has a ballistic coefficient of 11, we mean that it will suffer loss of velocity at only one-eleventh the rate suffered by a projectile of standard form, one pound weight, and one inch caliber, under normal atmospheric conditions.

The ballistic coefficient of the standard projectile under normal conditions is represented by the equation

$$C = \frac{w}{cd^2}$$

in which $c$ is called the coefficient of form and is unity for an ogive struck with a radius of two calibers. It relates merely to the shape of the head of the projectile.

The values of $c$ for ogives struck with different radii, expressed in calibers, are taken as follows from page 39, *Ballistics*, Part II, and page 295, *Notes on Ballistics*, JOURNAL U. S. ARTILLERY November-December, 1909, by Major Alston Hamilton:

| | | | | | | |
|---|---|---|---|---|---|---|
| $n$ = | 2 | 3 | 4 | 5 | 6 | 7 |
| $c$ = | 1.00 | 0.82 | 0.71 | 0.64 | 0.58 | 0.54 |

These agree with the most recent experiments at Indian Head and at Sandy Hook.

Our long-pointed projectiles are struck with a radius of ogive of $n = 7$ calibers; yet for the 12-inch projectile $i = 0.63$.

In other words, the oblique presentation, etc., so reduces the value expected from the point that the gain is limited to a projectile of standard form having a radius of ogive of about five calibers, flying exactly head-on, and conforming to the laws on which Table II is based.

See Chap. II, *Ballistics*, Part I; pages 187-189, and 223-225, *Artillery Circular N;* and Introduction, *Artillery Circular M.*

It will be noticed that in some of the range tables computed by the Ordnance Department the expression $\frac{\beta c}{f_a}$ is used instead of the factor *i*.

*Striking velocity.*—The velocity of the projectile in feet per second in the direction of the line of impact, and at the point of impact.

*Jump.*—Either the difference between the sight elevation and the sight angle of departure, or the difference between the quadrant angle of elevation and the quadrant angle of departure. In Case I the piece is given an angle of elevation with reference to the line of sight; in Case II and Case III the piece is given an angle of elevation with reference to the horizontal; in either case the shock of discharge may change the inclination of the axis of the bore at the instant of departure from the inclination at which the piece was laid. This change in inclination is called jump. The jump may be either positive (increasing the inclination) or negative (decreasing the inclination), or may be zero (in which case the inclination is unchanged), "depending upon the kind of carriage and platform employed, the length of the bore, * * * and the angle of elevation." (For a study of jump, see JOURNAL U. S. ARTILLERY, Vol. 36, Sept.-Oct., 1911, page 176; Vol. 35, Jan.-Feb., 1911, pages 63-75.)

*Angle of elevation.*—The inclination of the axis of the bore to the line of sight, measured in a vertical plane, when the piece is laid. Often called *sight elevation.*

*Quadrant angle of elevation.*—The inclination of the axis of the bore to the horizontal, when the piece is laid.

*Sight angle of departure.*—The inclination of the line of departure to the line of sight, measured in a vertical plane.

Jump = $AG'B$
Angle of departure = $IG'B$
Angle of elevation, or sight elevation = $TG'A$
Sight angle of departure = $TG'B$

Quadrant angle of departure = $CG'B$
Quadrant angle of elevation = $CG'A$

*Line of impact.*—The tangent to the trajectory at the point of impact; or, the direction of motion of the projectile at the instant of impact.

*Angle of impact.*—The inclination of the line of impact to the surface hit at the point of impact.

*Angle of incidence.*—The inclination of the line of impact to the normal to the surface hit at the point of impact.

These last two angles are of interest chiefly in the study of armor attack and the computations of perforations to be expected.

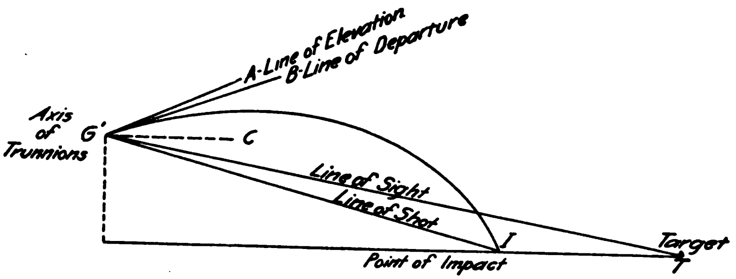

Fig. 2.

Table II.—For a thorough understanding of its significance, consult *Artillery Circulars, M* and *N*. It consists of a number of tables, each table being for a certain muzzle velocity, and designed to display certain computed secondary functions in such a manner as to be most convenient for ballistic computations. Having given a horizontal distance $X$ (in feet), and a given $C$, and a given $V$, for the ratio $\frac{X}{C}$ $(= Z)$ there can be found, of chief interest, the value $A \left(= \frac{\sin 2\varphi}{C}\right)$ for the given muzzle velocity. Hence from $A$ we can determine $\varphi$, the required angle of departure. Other elements of the trajectory can likewise be computed from the formulæ given later on, which show the relation of the element that we desire to compute to the proper function to be found opposite the ratio $Z = \frac{X}{C}$. For convenience, an abridged Table II is appended hereto, including the values of $A$ for $V = 2150$, $V = 2250$, and $V = 2350$ as determined by double interpolation from the 2100, 2200, 2300, and 2400 f.s. tables.

There are also appended the tables for muzzle velocities from 2000 to 3000 inclusive for values of $Z$ from 100 to 7000.

In the range tables for capped projectiles it is seen that the values of $C$ vary with the range. These values are based on assumptions which are no longer considered to represent the best practice; but it is sufficiently exact to take the nearest tabular value from the range table for any range considered. Then the value of $C_1$ (for the day) $= \frac{\delta_1}{\delta} \cdot f_w \cdot C$ (range table value).

*Problem 1*

Thus for the 12-inch gun and capped projectile, range 8000, barometer 29″, thermometer 40°F., and a range component of wind 20 miles per hour against the projectile, we have:

From Table A,

Atmosphere factor = .98

$$\text{Wind factor, } f_w = 1 \pm \frac{2W_xT^{5/4}}{X}$$

(The positive sign is used when the wind is accelerating, and the negative sign when the wind is retarding.)

$$\begin{aligned} \log 2\,W_x &= \log 40 = 1.60206 \\ 5/4 \log T &= 5/4 \log 13.06 = 1.39493 \\ \operatorname{colog} X &= \operatorname{colog} 24000 = \underline{5.61979-10} \\ &\log .04138 = 8.61678 \end{aligned}$$

$f_w = 1 - .04 = .96$

(Range table) $\log C = 0.90971$

$$\begin{aligned} \log \frac{\delta_1}{\delta} &= \log .98 = 9.99122-10 \\ \log f_w &= \log .96 = \underline{9.98227-10} \end{aligned}$$

$$\log C_1 \text{ (for the day)} = 0.88320 = \log 7.642$$

For the range tables for the long pointed projectiles it is seen that the value of $C$ is taken as constant throughout the range. The expression for $C$ under range table conditions is $C = \frac{w}{id^2}$.

*Problem 2*

Assuming the same range, atmosphere, and wind as in the previous problem, we have for the 12-inch gun and long pointed projectile:

## HAMILTON'S FORMULÆ

$$\frac{t}{d} = P_v \sqrt{\frac{w}{d^3}}$$

which reduces to,

$$t = P_v \sqrt{\frac{w}{d}}$$

in which $t$ is the thickness of K.C. armor that a capped A.P. shot is to be expected to perforate at normal impact. $P_v$ is a function of $v$ to be taken from Table P which gives values of $P_v$ with $v$ as an argument; $w$ and $d$ are, respectively, the weight of the A.P. shot in pounds and its diameter in inches.

$$\text{Wind deflection (degrees)} = \frac{W_y Z}{V} D_w^\circ$$

in which $W_y$ is the cross-component of the wind in miles per hour, and $D_w^\circ$ is the wind deflection function to be taken from Table D.

$$\text{Drift (degrees)} = (1 - K)\frac{d^3}{wn}(\varphi + \omega)\sec\varphi$$

in which $K$ is the drift constant, $n$ the number of calibers which the projectile would have to move along the bore in order to make one turn at the final rate of twist. $n$ is ordinarily 25 for direct fire guns of high power in our service, and the twist is to the right.

As regards the precision to be attempted in the computations, the following is quoted from page 3, *Artillery Circular N*, Series of 1893, by Colonel James M. Ingalls, U. S. A.:

> Logarithms are habitually employed in making the numerical computations, as it is believed that by their use a considerable saving of time and labor is effected and the liability of error reduced to a minimum. In the absence of a table of logarithms, however, most of the examples can be worked out by the four fundamental rules of arithmetic. Five place logarithms are sufficient for the accurate solution of all gunnery problems, and four place logarithms can often be used to advantage.

## APPLICATIONS OF THE FORMULÆ

### TARGET IN THE INITIAL PLANE

### *Problem 3*

Given $R$, $C$, and $V$, to determine $\varphi$.

$R = 8000$; $C = (1.07168)$; $V = 2250$.

See Table II, appended.

$$Z = \frac{X}{C}$$

$$\begin{aligned} \log X = 24000 &= 4.38021 \\ \operatorname{colog} C &= 8.92832-10 \\ \hline \log Z &= 3.30853 \\ Z &= 2035 \end{aligned}$$

For $V = 2250$ and $Z = 2035$, $A = .01513 + \frac{35}{100} \times 91 = .01545$

$\text{Sin } 2\varphi = AC$

$$\begin{aligned} \log A &= 8.18893-10 \\ \log C &= 1.07168 \\ \hline \log \sin 2\varphi &= 9.26061 \\ 2\varphi &= 10^\circ\, 30' \\ \varphi &= 5^\circ\, 15' \end{aligned}$$

which checks closely enough with the range table for the 12-inch gun and long pointed projectile.

### *Problem 4*

Given $R$, $C$, and $V$, to determine $\varphi$.
$R = 8000$; $C = (1.07168)$; $V = 2230$.
$R$ and $C$ being the same as in problem 3, we get
$Z = 2035$.

$(V = 2200)\ A = .01585 + \frac{53}{100} \times 95 = .01618$

$(V = 2250)\ A =$ (see Prob. 3) $.01545$; $\Delta_v = -73$

$(V = 2230)\ A = .01618 + \frac{30}{50} \times (-73) = .01574$

$\text{Sin } 2\varphi' = AC$

$$\begin{aligned} \log A &= 8.19700-10 \\ \log C &= 1.07168 \\ \hline \log \sin 2\varphi' &= 9.26868-10 \\ 2\varphi' &= 10^\circ\, 41'.9 \\ \varphi' &= 5^\circ\, 21' \end{aligned}$$

We see that 6′ greater elevation is required than when $V = 2250$ f.s.

### *Problem 5*

Given C, $V$, and $\varphi$, to determine $R$.
$C = (1.07168)$; $V = 2250$; $\varphi = 6^\circ\, 4'$
$\text{Sin } 2\varphi = AC$

$$\begin{aligned} \log \sin 2\varphi = \log \sin 12^\circ 8' &= 9.32260-10 \\ \text{colog } C &= 8.92832-10 \\ \hline \log A &= 8.25092-10 \\ A &= .01782 \end{aligned}$$

For ($V = 2250$) and $A = .01782$, $Z = 2200 + \frac{86}{94} \times 100$ $= 2291.5$

$$Z = \frac{X}{C}$$

$$\begin{aligned} \log Z = \log 2291.5 &= 3.36011 \\ \log C &= 1.07168 \\ \hline \log X &= 4.43179 \\ X &= 27027 \\ R &= 9009 \text{ yds.} \end{aligned}$$

*Problem 6*

Given $V$, $\varphi$, and $R$, to determine $C$.
$V = 2250$; $\varphi = 5^\circ 49'$; $R = 8400$.

$$C' = \frac{\sin 2\varphi}{X}$$

$$\begin{aligned} \log \sin 2\varphi = \log \sin 11^\circ 38' &= 9.30459-10 \\ \text{colog } X = \text{colog } 25200 &= 5.59860-10 \\ \hline \log C' &= 4.90319-10 \end{aligned}$$

($V=2200$) $\log C' = 4.9032-10$ $\quad Z = 2100 + \frac{2}{41} \times 100 = 2105$

$\Delta = 959$

($V=2300$) $\log C' = 4.9032-10$ $\quad Z = 3000 + \frac{27}{42} \times 100 = 3064$

($V=2250$) $\log C' = 4.9032-10$ $\quad Z = 2105 + \frac{50}{100} \times 959 = 2585$

$$Z = \frac{X}{C}$$

$$\begin{aligned} \log X &= 4.40140 \\ \text{colog } Z = \text{colog } 2585 &= 6.58923-10 \\ \hline \log C &= .99063 \end{aligned}$$

which is practically the log $C$ for the 10-inch long pointed projectile.

*Problem 7*

Given $\varphi$, $R$, and $C$, to determine $V$.

$\varphi = 6° 8'$, $R = 9000$, $C = (1.07168)$

$$Z = \frac{X}{C}$$

$$\begin{aligned} \log X = \log 27000 &= 4.43136 \\ \operatorname{colog} C &= 8.92832 - 10 \\ \hline \log Z &= 3.35968 \\ Z &= 2289 \end{aligned}$$

$$\sin 2\varphi = AC$$

$$\begin{aligned} \log \sin 2\varphi = \log \sin 12° 16' &= 9.32728 - 10 \\ \operatorname{colog} C &= 8.92832 \\ \hline \log A &= 8.25560 - 10 \\ A &= .01801 \end{aligned}$$

With Z as an argument, we look through Table II to find the two successive velocities whose $A$'s for $Z = 2289$ bracket the value $A = .01801$. Then we interpolate for the velocity.

$$(V=2200)\ Z=2289 \qquad A = .01776 + \frac{89}{100} \times 99 = .01864$$

$$\Delta = -.00084$$

$$(V=2250)\ Z=2289 \qquad A = .01696 + \frac{89}{100} \times 94 = .01780$$

$$V = 2200 + \frac{.01801 - .01864}{-.00084} \times 50 = 2200 + \frac{-63}{-84} \times 50 = 2238 \text{ f.s.}$$

### *Problem 8*

The following is quoted, with a few alterations, from *Notes on Ballistics*, by Major Alston Hamilton (pages 259 and 260, JOURNAL U. S. ARTILLERY, Nov.-Dec., 1909).

> In dealing with the jump of the piece it is necessary to find how far the trajectory should naturally fall away from the line of departure, due to the action of gravity and to the vertical component of the air resistance. This is done as follows:
>
> $$\frac{y}{x} = \tan \varphi' \left(1 - \frac{aC}{\sin 2\varphi'}\right)$$
>
> or
>
> $$y = x \tan \varphi' - \frac{aCx \tan \varphi'}{\sin 2'\varphi}$$
>
> That is
>
> $$x \tan \varphi' - y = \frac{aCx}{2 \cos^2 \varphi'}$$
>
> for this purpose, $\cos^2 \varphi'$ may be taken as unity for direct fire, we

$$\text{Natural drop} = \frac{aCx}{2}\text{ ft.}$$
$$= \tfrac{1}{2}\, aC^2 z \text{ ft.}$$
$$= 6aC^2 z \text{ inches.}$$

* * * * * * * * * * * *

The manner of solving this problem in general will be evident from the illustration given below:

Given $V = 2234$; barometer, 30.31; thermometer, 37°; wind velocity, 12 miles per hour; azimuth of wind, 128°; azimuth of fire, 316°; quadrant elevation, $Q = 10^\circ\ 27'$; drop of projectile from line of bore sights, measured on jump screen, 23 in. Deviation on screen, 0.0 in. Measured range, 14,091 yards; measured deflection, 0°.44 right; time of flight (observed) 23.13 seconds; height of tide, $h$, 2.95 feet; * * * distance, $D$, from muzzle to screen 366.2 feet; distance, $b$, from axis of trunnions to muzzle of piece, 24.1 feet; $D + b$, 390.3 feet; range in feet, 42,273; 12-inch B.L.R.; weight of projectile, 1046 lbs.; shot [long pointed]; radius of ogive, 7 calibers; twist, 1 turn in 25 calibers.*

Determine $i$ and $K$.

From Table C, assume

$$C = 0.54$$

From Table A,

$$\frac{\delta_1}{\delta} = .933$$

For the short distance to the screen assume $f_w = 1$.

$$C = \frac{\delta_1}{\delta} \cdot \frac{w}{c\ d^2} = .933\frac{1046}{0.54 \times 144} = 12.55$$

Now for the screen

$$X = D = 366.2$$

Hence

$$\frac{X}{C} = Z = \frac{366.2}{12.55} = 29$$

To find $a$ we have, with $z = 29$ and $V = 2234$

$$z = 29$$

$(V = 2200)$ $a = .000194$ $\Delta = -.000008$

$(V = 2250)$ $a = .000186$

$(V = 2234)$ $a = .000194 - \frac{34}{50} \times .000008 = .000192$

Hence from natural drop $= 6aC^2z$ inches,

---

* While from this point on, the general method employed in this problem is that Major Hamilton employed in the reference cited, yet it is not printed in the smaller type because the agreement is not so close as has been the case up to this point.

$$\begin{aligned}
\log 6 &= 0.77815\\
\log a &= 6.28330 - 10\\
2\log C &= 2.19728\\
\log z &= 1.46240\\
\hline
\text{log natural drop} &= 0.72113\\
\text{Natural drop} &= 5.26 \text{ inches.}
\end{aligned}$$

The measured drop is 23 inches; hence the drop due to negative jump is $23 - 5.3 = 17.7$ inches.

Now this distance is measured on a screen at a distance from the axis of the trunnions which equals $D + b$, or 390.3 feet, or 4684 inches. Then, since a radian is 3438′, we have

$$\text{Jump} = -\frac{17.7}{4684} \times 3438' = -13'$$

Hence the quadrant angle of departure, $\varphi_x$, is the quadrant elevation $10° 27' - 13' = 10° 14'$.

To find $\epsilon$ (see Fig. 2):

The height of the trunnions above mean low water was 24.7 feet; the height of the tide was 2.5 feet; the curvature of the earth at this range (see Table K) is 42.8 feet.

$$\begin{aligned}
\text{Hence } \epsilon &= 3438' \cdot \frac{42.8 + 24.7 - 2.5}{42{,}273}\\
&= 3438 \cdot \frac{65}{42{,}273} = 5'.3
\end{aligned}$$

$$\begin{aligned}
\text{Hence } \varphi' &= \varphi_x + \epsilon = 10° 14' + 5'.3 = 10° 19'.3\\
2\varphi' &= 20° 38'.6
\end{aligned}$$

We now know $V$, $\varphi'$, and $X$, and can calculate

$$\log C' = \frac{\sin 2\varphi'}{X}$$

with which to enter Table II, *Artillery Circular M*, or Table B, appended, and find thence, by interpolation, the value of $C_1$ (for the day), as follows:

$$\begin{aligned}
\log \sin 2\varphi' &= \log 20° 38'.6 = 9.54722 - 10\\
\text{colog } X &= \text{colog } 42{,}273 = 5.37394 - 10\\
\hline
\log C' &= 4.92116 - 10\\
\text{Log } C' \text{ to four places} &= 4.9212 - 10
\end{aligned}$$

With this value of log $C'$ we get

| $V$ | $Z$ | $A$ |
|---|---|---|
| 2200 | 2540 | .02120 |
| 2300 | 3482 | .02905 |
| Δ (100) | 942 | 785 |
| Δ 34 | 320 | 267 |
| 2234 | 2860 | .02387 |

$$\begin{array}{rlrl}
Z & = \dfrac{X}{C} & \sin 2\varphi & = AC \\
\log X & = 4.62606 & \log \sin 2\varphi & = 9.54722-10 \\
\operatorname{colog} Z & = \underline{6.54364-10} & \operatorname{colog} A & = \underline{1.62215} \\
\log C_1 & = 1.16970 & \log C_1 & = 1.16937
\end{array}$$

Hence it is seen that the values of log $C_1$ agree very closely as secured through different methods of interpolation. The corresponding values of $C_1$ are 14.781 and 14.77

Take the mean value, $C_1 = 14.776$ (for the day). But this $C_1$ = the range table $C$ multiplied by the atmosphere and wind factors. Designating the $C$ for the day as $C_1$,

$$C_1 = \frac{\delta_1}{\delta} \times f_w \times C$$

To find $f_w$, note that

$$f_w = 1 + \frac{2\,W_x\,T^{5/4}}{X}$$

The positive sign is used for a head wind and the negative sign for a wind from the rear.

In this case the azimuth of fire is 316° and the azimuth from which the wind is blowing is 128°. Hence the wind is blowing from the right rear and makes an angle of 360° − 316° + 128° = 172° with the plane of fire, or an acute angle of 8°. The range component is therefore $W \cos 8°$, and the cross component from the right is $W \sin 8°$ and tends to diminish the drift.

Wind 12 miles per hour:

$$\begin{array}{rlrl}
\log W & = 1.0792 & \log W & = 1.0792 \\
\log \cos 8° & = \underline{9.9958} & \log \sin 8° & = \underline{9.1436} \\
\log W_x & = 1.0750 & \log W_y & = 0.2228 \\
W_x & = 11.885 & W_y & = -1.670
\end{array}$$

To find $f_w$. since $T = 23.13$

$$\begin{array}{rl}
\log W_x & = 1.0750 \\
5/4 \log T & = 1.7052 \\
\log 2 & = 0.3010 \\
\operatorname{colog} X & = \underline{5.3739} \\
\log .029 & = 8.4551-10
\end{array}$$

$$f_w = 1 + .029 = 1.029$$

$$\text{(Table A)} \frac{\delta_1}{\delta} = .933$$

$$C = \frac{C_1}{\frac{\delta_1}{\delta} \cdot f_w}$$

$$\begin{aligned} \log C_1 &= \log 14.776 = 1.16955 \\ \operatorname{colog} \frac{\delta_1}{\delta} &= \operatorname{colog} .933 = 0.03012 \\ \operatorname{colog} f_w &= \operatorname{colog} 1.029 = 9.98759-10 \\ \log C \text{ under range table conditions} &= 1.18726 \end{aligned}$$

$$C = \frac{w}{i\,d^2} \text{ or } i = \frac{w}{C\,d^2}$$

$$\begin{aligned} \log W &= \log 1046 = 3.01953 \\ \operatorname{colog} C &= 8.81274-10 \\ \operatorname{colog} d^2 &= \operatorname{colog} 144 = 7.84164-10 \\ \log i &= 9.67391-10 \\ i &= .47 \end{aligned}$$

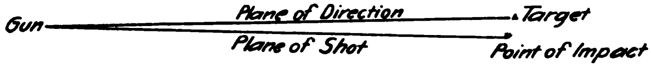

FIG. 3. 1554

## Lateral Deviations or Deflections

The *line of direction* is the line from the pintle center to the aiming point, or to the center of the target, at the instant the shot strikes.

The *plane of direction* is the vertical plane containing the line of direction.

The *plane of departure* is the vertical plane containing the line of departure.

The *plane of sight* is the vertical plane containing the line of sight at the instant of departure. Range firings are ordinarily conducted at a fixed target, or at an aiming point. In this case the plane of departure coincides with the plane of sight. That is, the piece is laid on the target without lateral corrections. Then the fall of the shot to the right or left of the plane of direction is observed, and is expressed in angular measure. The observed angular horizontal divergence of the point of impact is modified by the divergence caused by the lateral component of the wind. This gives the drift, and ultimately the constant for the projectile.

To find the drift constant, *K*, the observed direction must be corrected for the cross wind component.

$$W_y = -1.67 = -5/3$$

The value of the wind deflection is,

$$\text{Wind deflection (degrees)} = \frac{WZ}{V} \times D_w^\circ$$

Now for $V = 2234$, from Table D we have for $Z = 2860$

$$D_w^\circ = 0^\circ.0061$$

Hence,

$$\text{Wind deflection} = -5/3 \times \frac{2860}{2234} \times .0061 = -.013$$

The observed deflection was 0°.44 right. This increased by .013 becomes 0.45. We have, then, from the formula for drift

$$D^\circ = (1-K)\frac{d^3}{wn}(\varphi' + \omega') \sec \varphi' (*)$$

$$0.45 = (1-K)\frac{1728}{1046 \times 25}(\varphi' + \omega') \sec \varphi'$$

It is necessary to find $\omega'$. We have

$$V = 2234$$
$$Z = 2860$$
$$\varphi' = 10^\circ\ 14'$$

Hence for $Z = 2860$ from Table B,

| $V$ | $\log B'$ | $\Delta$ |
|---|---|---|
| 2200 | .1073 | $-10$ |
| 2300 | .1063 | |
| 2234 | $.1073 - \frac{34}{100} \times 10 = .1070$ | |

$$\tan \omega' = B' \tan \varphi'$$

$$\log \tan \varphi' = \log \tan 10^\circ\ 14' = 9.25654 - 10$$
$$\log B' = 0.10700$$
$$\log \tan \omega' = 9.36354 - 10$$
$$\omega' = 13^\circ\ 0'.3 = 13^\circ$$

$$\varphi' = 10^\circ.23$$
$$\varphi' + \omega' = 23^\circ.23$$
$$\log \sec \varphi' = .00697$$

Hence

$$(1-K) = \frac{.045}{23.23 \sec \varphi'} \cdot \frac{1046 \times 25}{1728}$$

---

* From Hamilton's *Ballistics*, Part I, page 33.

$$\begin{aligned}
\log 0.45 &= 9.65321-10\\
\text{colog } 23.23 &= 8.63395-10\\
\text{colog sec } \varphi' &= 9.99303-10\\
\log 1046.0 &= 3.01953\\
\log 25.0 &= 1.39794\\
\text{colog } 1728.0 &= 6.76246-10\\
\hline
\log(1-K) &= 9.46012-10\\
1-K &= .2885\\
K &= .712
\end{aligned}$$

To summarize:

$$\begin{aligned}
i &= .47\\
K &= .712\\
j^{*} &= -13'
\end{aligned}$$

## THE RANGE TABLE

The range table for a direct fire gun and its type projectile exhibits principally the angle of departure as a function of the range under an assumed set of conditions called "range-table conditions"; these are:

(*a*) That the gun and target are on the same level.

(*b*) A constant value for the ballistic coefficient.

(*c*) Law of retardation as assumed in Table II.

(*d*) Normal atmosphere; i.e., $\frac{\delta_1}{\delta} = 1$, atmosphere 78% saturated with moisture.

(*e*) No wind.

(*f*) Normal muzzle velocity.

The elements of the trajectory shown as functions of the range are:

1. Time of flight.
2. Angle (and slope) of fall.
3. Maximum ordinate.
4. Striking velocity.
5. Perforation of Krupp armor.
6. Deviation from the plane of fire due to: (1) drift; and (2) component of wind of 10 miles per hour perpendicular to the plane of fire.

### COMPUTATION OF A RANGE TABLE

(NOTE.—The range table value of $C$ here given does not correspond with that to be found in the range table for the

---

* Jump.

12-inch gun and long-pointed projectile. One who desires to gain facility in the use of Table II may assume certain values in the range table and solve for others, thus framing his own problems and checking his results with values in the range table.)

Assume the values determined in Problem 8. We have found that log $C$ (range-table conditions) = 1.18726. Compute the line of the range table for 10,000 yards:

$$\begin{aligned}\log X = \log 30{,}000 &= 4.47712\\ \operatorname{colog} C &= 8.81274-10\\ \hline \log Z &= 3.28986\\ Z &= 1949\end{aligned}$$

(See Tables B and II.)

$$(V = 2250)\ Z = 1949,\ A = .01468$$

$$Z = 1949$$

| $V$ | log $B'$ | $u$ | $T'$ |
|---|---|---|---|
| 2200 | .0725 | 1712 | 1.005 |
| 2300 | .0716 | 1796 | .960 |
| | .1441 | 3508 | 1.965 |
| 2250 | .0721 | 1754 | .983 |

(See Table D.) $V = 2250$, $Z = 1949$, $D_w^\circ = .0059$

To find $\varphi$, $\operatorname{Sin} 2\varphi = AC$

$$\begin{aligned}\log A = \log .01468 &= 8.16672-10\\ \log C &= 1.18726\\ \hline \log \sin 2\varphi &= 9.35398-10\\ 2\varphi &= 13^\circ\ 3'.5\\ \varphi &= 6^\circ\ 31'.8\end{aligned}$$

To find $T$, $T \doteq \dfrac{CT'}{\cos\varphi}$

$$\begin{aligned}\log C &= 1.18726\\ \log T' = \log .983 &= 9.99255-10\\ \operatorname{colog} \cos\varphi = \operatorname{colog} \cos 6^\circ\ 31'.8 &= 0.00283\\ \hline \log T &= 1.18264\\ T &= 15.23 \text{ seconds}\end{aligned}$$

To find $y_0$, $y_0 = 4.05T^2$

$$\begin{aligned}2 \log T &= 2.36528\\ \log 4.05 &= 0.60746\\ \hline \log y_0 &= 2.97274\\ y_0 &= 939 \text{ feet}\end{aligned}$$

[illegible]

To find [illegible]

[illegible]

.280 [illegible]

*Problem [illegible]*

*rift of Capped Projectiles; i.e., those not fitted with long* [illegible]

---

ee Hamilton's *Ballistics*, Part 1, Page 33.

"Take $K$ for shot and steel shell as 0.75; for C. I. shell as 0.80."

Capped C. I. shell are being fired as trial shots from a 10-inch B.L.R. $w = 604$; $\frac{\delta_1}{\delta} = 1$; $W = 0$; range to center of impact, 8000 yards; assume jump as $\pm 0$. Assume the piece to be laid accurately at the aiming point.

(*a*) If the gun pointer has his sight set at 3.00 and moves the vertical wire to each spalsh, what should the sight setting be?

(*b*) What deflection should be computed by the deflection board fitted with a leaf range scale for steel projectiles?

(*c*) What is the error at this range to be expected from the deflection board?

(See range table for 10-inch gun, and capped projectile.)

| | a | b |
|---|---|---|
| | C. I. Shell | Steel |
| $\log (1-K) = \log .20$ | $= 9.3010$ | $\log .25 = 9.3979$ |
| $\log d^3 = \log 1000$ | $= 3.0000$ | 3.0000 |
| $\log (\varphi+\omega) = \log 14.4$ | $= 1.1584$ | 1.1584 |
| $\log \sec \varphi = \log \sec 6°$ | $= .0025$ | .0025 |
| $\text{colog } w = \text{colog } 604$ | $= 7.2190$ | 7.2190 |
| $\text{colog } n = \text{colog } 25$ | $= 8.6021$ | 8.6021 |
| log drift | $= 9.2829$ | 9.3799 |
| drift | $= 0°.190$ | 0°.240 |

(*a*) The reading of the sight will be $3.00 - 0.19 = 2.81$. This is the correct setting of the sight.

(*b*) The deflection computed will be $3.00 - .24 = 2.76$.

(*c*) This would cause the projectile to fall $2.81 - 2.76 = 0°.05$ to the left, and would necessitate a flat correction of $+ 0°.05$.

## THE GRADUATION OF THE RANGE SCALE

At the present* writing no decision has been reached on the proposition of correcting for jump. If it is finally deemed practicable, the correction therefor will be incorporated in the graduation of the range scale. A method here outlined permits a battery commander to compute a table expressing the Range-Quadrant-angle-of-departure relation. Any material discrepancy between his table and the elevation table

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* November, 1914.

$$\Delta\varphi_h = h\frac{1134 + .005R}{R} \tag{3}$$

This last formula is convenient where a number of elevation tables for batteries on different heights of site are to be computed. The values of the fraction for successive ranges have been computed and tabulated.

$\Delta\varphi_J$ has not been determined yet.

The procedure for computing the Range-$\varphi_1$ relation for a gun will be possible as follows:

Select 9000 yards for an example for the 12-inch gun and long-pointed projectile; height of site, 200 feet; M.V:, 2250 f.s.

1. From the range table (Form 1014), $\varphi = 6° 4'$.
2. The correction for curvature of the earth $= - 2'.25$.
3. The correction for height of site $= - 26'.2$. (Equation (3).)

Hence the quadrant angle of departure for the gun is, $\varphi = 6° 4' - 2'.3 - 26'.2 = 5° 35'.5$.

If the line of departure makes an angle of 5° 35'.5 with the horizontal plane through the trunnions, we can expect the shot to fall at a horizontal distance of 9000 yards on the surface of the water, under range-table conditions.

5. Assume the verity of the jump curve appended to this article. At an angle of 5° 35'.5 the jump is seen to be about +1'.1. That is, the gun increases in elevation that amount at the instant of discharge.

Therefore, the *correction* at that elevation is $- 1'.1$.

6. $5° 35'.5 - 1'.1 = 5° 34'.4$.

If now the gun is fired with an elevation, $\varphi_1$ of 5° 34'.4, we can expect the quadrant angle of departure to be 5° 35'.5.

To graduate the range scale, the gun is given an elevation $\varphi_1 = 5° 34'.4$ and opposite the index is cut and numbered the 9000-yard range graduation.

At present, and until the range drums require regraduation for the long pointed projectiles, the graduation of the range scales is as follows:

1. Take $\varphi$ from the range table for the capped projectile.
2. Determine $\epsilon$ from *Artillery Note No. 29.*
3. $\varphi - \epsilon = \varphi_\epsilon$
4. Set the gun by the clinometer to $\varphi_\epsilon$, and opposite the index graduate the range drum.

| Range | F | $\Delta\varphi_K$ minutes | Range | F | $\Delta\varphi_K$ minutes |
|---|---|---|---|---|---|
| 8000 | .1468 | 2.00 | 17000 | .0717 | 4.25 |
| 200 | .1433 | 2.05 | 200 | .0709 | 4.30 |
| 400 | .1400 | 2.10 | 400 | .0701 | 4.35 |
| 600 | .1369 | 2.15 | 600 | .0694 | 4.40 |
| 800 | .1339 | 2.20 | 800 | .0687 | 4.45 |
| 9000 | .1310 | 2.25 | 18000 | .0680 | 4.50 |
| 200 | .1283 | 2.30 | 200 | .0673 | 4.55 |
| 400 | .1256 | 2.35 | 400 | .0666 | 4.60 |
| 600 | .1231 | 2.40 | 600 | .0659 | 4.65 |
| 800 | .1207 | 2.45 | 800 | .0653 | 4.70 |
| 10000 | .1184 | 2.50 | 19000 | .0647 | 4.75 |

### *Problem 10*

Assume a 12-inch gun, 200-ft. above mean low water, and firing long pointed projectiles. Compute an elevation table for ranges of 8000 to 10,000 yards inclusive. (See page 34.)

Due to the difficulty of reading the jump curve, it is well to check the column $\varphi_1$ by differences. It is seen that the second differences in column 3 are inconsistent and should probably be all equal to $+0'.1$. Working conversely from column 4, we get the adjusted first differences in column 5, and adjusted values of $\varphi_1$ in column 6 for further use.

Representing $\frac{\delta_1}{m}$ by $A$, and $\frac{\delta_2}{2m^2}$ by $B$, we have, generally, whatever the value of $m$,

$$\begin{aligned}
\Delta_1 &= A - (m-1)\,B \\
\Delta_2 &= A - (m-3)\,B = \Delta_1 + 2B \\
\Delta_3 &= A - (m-5)\,B = \Delta_2 + 2B \\
\Delta_4 &= A - (m-7)\,B = \Delta_3 + 2B \\
\Delta_5 &= A - (m-9)\,B = \Delta_4 + 2B
\end{aligned}$$

etc., etc., etc., *ad libitum*, according to the values of $m$.

For $m = 3$; $A = \delta_1/3$, and $B = \delta_2/18$
$m = 4$; $A = \delta_1/4$, and $B = \delta_2/32$
$m = 5$; $A = \delta_1/5$, and $B = \delta_2/50$
$m = 10$; $A = \delta_1/10$, and $B = \delta_2/200$

For our present work we wish to interpolate values of $\varphi_1$ for every 20 yards. Therefore we take $m = \frac{200}{20} = 10$

| Range<br>yds. | $\varphi$<br>deg. min. | $\Delta\varphi_K$<br>minutes | $\Delta\varphi_h$<br>minutes | $\varphi_x$<br>deg. min. | J<br>minutes | $\varphi_1$<br>deg. min. |
|---|---|---|---|---|---|---|
| 8000 | 5 15.2 | −2.00 | −29.36 | 4 43.8 | −2.0 | 4 41.8 |
| 200 | 5 24.7 | −2.05 | −28.66 | 4 54.0 | −1.8 | 4 52.2 |
| 400 | 5 34.2 | −2.10 | −28.00 | 5 04.2 | −1.7 | 5 02.5 |
| 600 | 5 44.1 | −2.15 | −27.38 | 5 14.6 | −1.6 | 5 13.0 |
| 800 | 5 54.0 | −2.20 | −26.78 | 5 25.0 | −1.5 | 5 23.5 |
| 9000 | 6 04.0 | −2.25 | −26.20 | 5 35.5 | −1.3 | 5 34.2 |
| 200 | 6 14.1 | −2.30 | −25.66 | 5 46.1 | −1.2 | 5 44.9 |
| 400 | 6 24.4 | −2.35 | −25.12 | 5 56.9 | −1.0 | 5 55.9 |
| 600 | 6 34.7 | −2.40 | −24.62 | 6 07.7 | −0.9 | 6 06.8 |
| 800 | 6 45.1 | −2.45 | −24.14 | 6 18.5 | −0.7 | 6 17.8 |
| 10000 | 6 55.6 | −2.50 | −23.68 | 6 29.4 | −0.5 | 6 28.9 |

| Column | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Range<br>yds. | $\varphi_1$<br>deg. min. | $\delta_1$<br>min. | $\delta_2$<br>min. | $(\delta_2)$<br>min. | $(\delta_1)$<br>min. | $\varphi_1$<br>deg. min. |
| 8000 | 4 41.8 | 10.4 | −0.1 | +0.1 | 10.3 | 4 41.8 |
| 200 | 4 52.2 | 10.3 | +0.2 | +0.1 | 10.4 | 4 52.1 |
| 400 | 5 02.5 | 10.5 | +0.0 | +0.1 | 10.5 | 5 02.5 |
| 600 | 5 13.0 | 10.5 | +0.3 | +0.1 | 10.6 | 5 13.0 |
| 800 | 5 23.5 | 10.8 | −0.2 | +0.1 | 10.7 | 5 23.6 |
| 9000 | 5 34.3 | 10.6 | +0.4 | +0.1 | 10.8 | 5 34.3 |
| 200 | 5 44.9 | 11.0 | −0.1 | +0.1 | 10.9 | 5 45.1 |
| 400 | 5 55.9 | 10.9 | +0.1 | +0.1 | 11.0 | 5 55.8 |
| 600 | 6 06.8 | 11.0 | +0.1 | +0.1 | 11.1 | 6 06.9 |
| 800 | 6 17.8 | 11.1 | . . . | . . . | 11.2 | 6 17.9 |
| 10000 | 6 28.9 | . . . | . . . | . . . | . . | 6 29.0 |

From 8000 to 8200,

$$A=\frac{\delta_1}{m}=\frac{10.3}{10}=1.03;\quad B=\frac{\delta_2}{2m^2}=\frac{0.1}{200}=.0005$$

$\Delta_1=A-(m-1)\,B=1.03-9\times.0005=1.0255$

$\Delta_2=\Delta_1+2B=1.0255+.001=1.0265$ $\qquad\Delta_7=1.0315$

$\Delta_3=1.0265+.001=1.0275$ $\qquad\Delta_8=1.0325$

$\Delta_4=1.0275+.001=1.0285$ $\qquad\Delta_9=1.0335$

$\Delta_5=1.0285+.001=1.0295$ $\qquad\Delta_{10}=1.0345$

$\Delta_6=1.0295+.001=1.0305$, etc.

Hence,

| $R$ | $\varphi_1$ deg. min. | | $\varphi_1$ deg. min. |
|---|---|---|---|
| 8000 | 4 41.8 | | 4 41.8 |
| 20 | 4 $41.8+\Delta_1=4^\circ\ 42.'8255$ | = | 4 42.8 |
| 40 | 4 $42.8255+\Delta_2=4^\circ\ 43'.8520$ | = | 4 43.9 |
| 60 | 4 $43.8520+\Delta_3=4^\circ\ 44'.8795$ | = | 4 44.9 |
| 80 | 4 $44.8795+\Delta_4=4^\circ\ 45'.9070$ | = | 4 45.9 |
| 8100 | 4 $45.9070+\Delta_5=4^\circ\ 46'.9365$ | = | 4 46.9 |
| 20 | 4 $46.9365+\Delta_6=4^\circ\ 47'.9670$ | = | 4 48.0 |
| 40 | 4 $47.9670+\Delta_7=4^\circ\ 48'.9985$ | = | 4 49.0 |
| 60 | 4 $48.9985+\Delta_8=4^\circ\ 50'.0320$ | = | 4 50.0 |
| 80 | 4 $50.0320+\Delta_9=4^\circ\ 51'.0655$ | = | 4 51.1 |
| 8200 | 4 $51.0655+\Delta_{10}=4^\circ\ 52'.1000$ | = | 4 52.1 |

Determine a new $A$ and a new $B$ for 8200 to 8400, and determine $\varphi_1$ for every 20 yards, etc.

For a further discussion see Appendix III, Hamilton's *Ballistics*, Part I.

Following such a system of interpolation, the following portion of an elevation table has been computed:

## ELEVATION TABLE

(Columns 1 and 5)

$R$-$\varphi_x$ TABLE

(Columns 1, 2, 3, and 4)

12-inch Gun and Long Pointed Projectile.

Height of Site, 200 feet.

| Range yds. | $\varphi$ deg. | $\varphi$ min. | $-\Delta\varphi_{hK}$ min. | $\varphi_x$ deg. | $\varphi_x$ min. | $\varphi_1$ deg. | $\varphi_1$ min. |
|---|---|---|---|---|---|---|---|
| 8000 | 5 | 15.2 | 31.4 | 4 | 43.8 | 4 | 41.8 |
| 20 | | 16.2 | 31.3 | | 44.9 | | 42.8 |
| 40 | | 17.1 | 31.2 | | 45.9 | | 43.9 |
| 60 | | 18.1 | 31.2 | | 46.9 | | 44.9 |
| 80 | | 19.0 | 31.1 | | 47.9 | | 45.9 |
| 8100 | | 19.9 | 31.0 | | 48.9 | | 46.9 |
| 20 | | 20.9 | 31.0 | | 49.9 | | 48.0 |
| 40 | | 21.8 | 30.9 | | 50.9 | | 49.0 |
| 60 | | 22.8 | 30.8 | | 52.0 | | 50.0 |
| 80 | | 23.8 | 30.8 | | 53.0 | | 51.1 |
| 8200 | | 24.7 | 30.7 | | 54.0 | | 52.1 |
| 20 | | 25.7 | 30.7 | | 55.0 | | 53.1 |
| 40 | | 26.6 | 30.6 | | 56.0 | | 54.2 |
| 60 | | 27.6 | 30.5 | | 57.1 | | 55.2 |
| 80 | | 28.5 | 30.5 | | 58.1 | | 56.2 |
| 8300 | | 29.5 | 30.4 | | 59.1 | | 57.3 |

| Range | $\varphi$ | | $-\Delta\varphi_{hx}$ | $\varphi_x$ | | $\varphi_1$ | |
|---|---|---|---|---|---|---|---|
| yds. | deg. | min. | min. | deg. | min. | deg. | min. |
| 20 | | 30.5 | 30.4 | 5 | 00.1 | | 58.3 |
| 40 | | 31.4 | 30.3 | | 01.1 | | 59.4 |
| 60 | | 32.4 | 30.2 | | 02.2 | 5 | 00.4 |
| 80 | | 33.3 | 30.2 | | 03.2 | | 01.5 |
| 8400 | | 34.3 | 30.1 | | 04.2 | | 02.5 |
| 20 | | 35.3 | 30.1 | | 05.2 | | 03.5 |
| 40 | | 36.3 | 30.0 | | 06.3 | | 04.6 |
| 60 | | 37.2 | 29.9 | | 07.3 | | 05.6 |
| 80 | | 38.2 | 29.9 | | 08.4 | | 06.7 |
| 8500 | | 39.2 | 29.8 | | 09.4 | | 07.7 |
| 20 | | 40.2 | 29.8 | | 10.4 | | 08.8 |
| 40 | | 41.2 | 29.7 | | 11.5 | | 09.9 |
| 60 | | 42.1 | 29.6 | | 12.5 | | 10.9 |
| 80 | | 43.1 | 29.6 | | 13.5 | | 11.9 |
| 8600 | | 44.1 | 29.5 | | 14.6 | | 13.0 |
| 20 | | 45.1 | 29.5 | | 15.6 | | 14.1 |
| 40 | | 46.1 | 29.4 | | 16.7 | | 15.1 |
| 60 | | 47.1 | 29.4 | | 17.7 | | 16.2 |
| 80 | | 48.1 | 29.3 | | 18.8 | | 17.2 |
| 8700 | | 49.1 | 29.3 | | 19.8 | | 18.3 |
| 20 | | 50.0 | 29.2 | | 20.8 | | 19.3 |
| 40 | | 51.0 | 29.2 | | 21.9 | | 20.4 |
| 60 | | 52.0 | 29.1 | | 22.9 | | 21.5 |
| 80 | | 53.0 | 29.0 | | 24.0 | | 22.5 |
| 8800 | | 54.0 | 29.0 | | 25.0 | | 23.6 |
| 20 | | 55.0 | 28.9 | | 26.1 | | 24.7 |
| 40 | | 56.0 | 28.9 | | 27.1 | | 25.7 |
| 60 | | 57.0 | 28.8 | | 28.2 | | 26.8 |
| 80 | | 58.0 | 28.8 | | 29.2 | | 27.9 |
| 8900 | | 59.0 | 28.7 | | 30.3 | | 28.9 |
| 20 | 6 | 00.0 | 28.7 | | 31.3 | | 30.0 |
| 40 | | 01.0 | 28.6 | | 32.4 | | 31.1 |
| 60 | | 02.0 | 28.6 | | 33.4 | | 32.2 |
| 80 | | 03.0 | 28.5 | | 34.5 | | 33.3 |
| 9000 | | 04.0 | 28.5 | | 35.5 | | 34.3 |

Assume the following: Range to target, 8500 yards; tide, 0; wind, none; atmosphere, normal; muzzle velocity, 2250 f.s.; projectile, long pointed; gun, 12-inch.

The piece should be given a quadrant elevation of $\varphi_1 = 5° 7'.7$. (The range setting will be 8500 yards.) When the piece is fired, the average jump will give a quadrant angle of departure of $\varphi_x = 5° 9'.4$.

Fig. 6 shows diagrammatically the relations between the range table angle of departure, $\varphi$, and the quadrant angle of

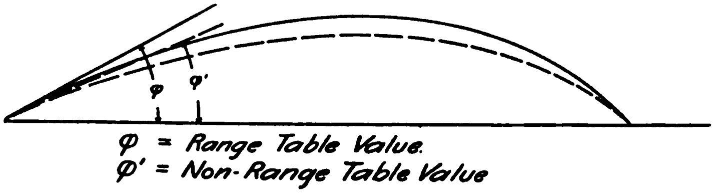

$\varphi$
$\varphi'$
$\varphi$ = Range Table Value.
$\varphi'$ = Non-Range Table Value

FIG. 4. 1555

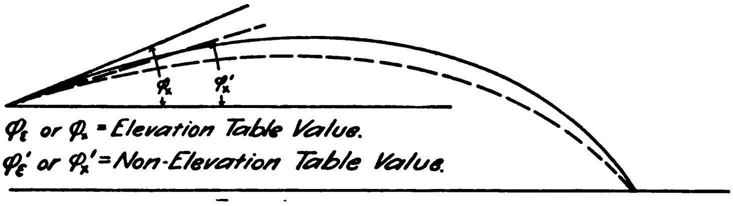

$\varphi_x$
$\varphi_x'$
$\varphi_\varepsilon$ or $\varphi_x$ = Elevation Table Value.
$\varphi_\varepsilon'$ or $\varphi_x'$ = Non-Elevation Table Value.

FIG. 5. 1556

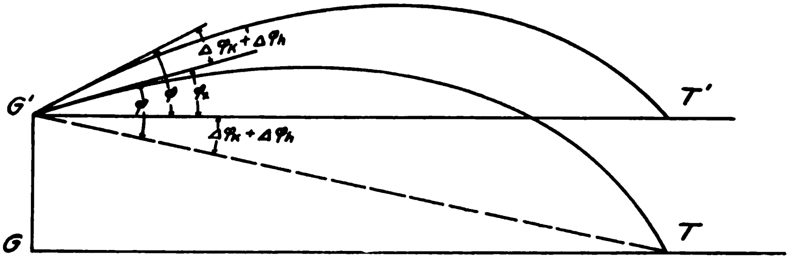

$\Delta\varphi_x + \Delta\varphi_h$
$G'$
$\varphi$
$\varphi$
$\varphi_x$
$T'$
$\Delta\varphi_x + \Delta\varphi_h$
$G$
$T$

FIG. 6. 1557

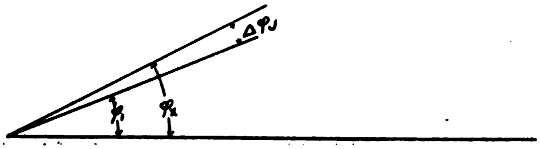


FIG. 7. 1558

[illegible]

[illegible]

[illegible]

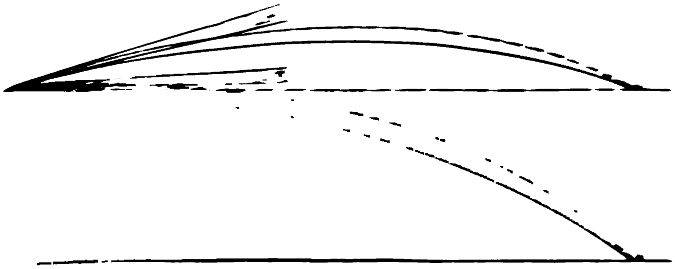


FIG. 4

It is assumed that by applying the same Δφ (= Δφ_x) to φ, we can cause the shot to range to the same horizontal distance under the same variations in V and C, no matter how great the height of site of the gun within service limits (see Figs. 5 and 8).

The order of procedure can be stated to be as follows:

1. For any non-range-table condition of V or C, assume the target to be in the initial plane, and solve for the required $\varphi'$.

2. Take $\varphi$ for the range from the range table by interlation where necessary. (NOTE: It is preferable for this rpose not to use the values in the column headed "Change elevation for 10 yards in range.")

3. $\varphi' - \varphi = \Delta\varphi$.

4. Determine $\varphi_x$ for the range from your computed table for long-pointed projectiles (or $\varphi_e$ from the quad-elevation table for capped projectiles).

5. To $\varphi_x$ (or $\varphi_\epsilon$) algebraically add $\Delta\varphi$ to get $\varphi'_x$ (or $\varphi'_\epsilon$).

6. In your computed $R$-$\varphi_x$ table for long pointed projectiles (or $\varphi_\epsilon$ table for capped projectiles), determine by interpolation the range corresponding to your $\varphi'_x$ (or $\varphi'_\epsilon$). When the gun is set for this range you will have the proper quadrant angle of departure, or angle of departure.

7. From the range setting determined in 6, subtract the actual range to the target. This will give the $\Delta R$ (range correction reference number) which, when applied to the range scale, will cause the proper change in the angle of departure.

*Problem 11*

Given: 12-inch gun and long pointed projectile; range to target, $T'$, 8500 yards; $C = 11.7945$; $V = 2215$ f.s.; height of site, 200 feet.

1. Solve for target as if in the initial plane.

$$Z = \frac{X}{C}$$

$$\begin{aligned}
\log X = \log 25500 &= 4.40654 \\
\text{colog } C &= \underline{8.92872-10} \\
\log Z &= 3.33526 \\
Z &= 2164
\end{aligned}$$

$\sin 2\varphi' = AC$

| For $Z$ = 2164. | $A$ | $\Delta$ |
|---|---|---|
| ($V$ = 2200) | .01741 | −82 |
| ($V$ = 2250) | .01659 | |

$$(V = 2215) \qquad A = .01741 - 82 \times \frac{15}{50} = .01716.$$

$$\begin{aligned}
\log A = \log .01716 &= 8.23451-10 \\
\log C &= \underline{1.07168} \\
\log \sin 2\varphi' &= 9.30619-10 \\
2\varphi' &= 11^\circ\, 40'.6 \\
\varphi' &= 5^\circ\, 50'.3
\end{aligned}$$

2. Referring to the range table (Form 1014), we see that $\varphi = 5^\circ\, 39'.2$ for 8500 yards.

3. Therefore, to compensate for the 35 f.s. reduction in velocity, we must increase our angle of departure by $\varphi' - \varphi = 5^\circ\, 50'.3 - 5^\circ\, 39'.2 = +11'.1 = \Delta\varphi$

4. Referring to our elevation table, we see that the quadrant angle of departure, $\varphi_x$, for 8500 yards is $5^\circ\, 09'.4$. The angle of departure must be increased by $\Delta\varphi$, wherefore,

5. $\varphi'_x = \varphi_x + \Delta\varphi = 5^\circ\, 09'.4 + 11'.1 = 5^\circ\, 20'.5$

6. What range setting will give us this angle of departure, 5° 20′.5?

Referring again to the $R - \varphi_x$ table we see by interpolation that the range setting will be

$$8700+20\times\frac{20.5-19.8}{20.8-19.8}=8700+20\times\frac{7}{1.0}=8714 \text{ yards.}$$

7. Therefore the change in the angle of departure is obtained by a change in the range setting of

$$8714 - 8500 = +214 = \Delta R \text{ on the range scale.}$$

This is the range correction reference number to be applied at the range scale.

In the operation of a range board fitted with a range correction chart for the 12-inch gun and long pointed projectile, it will be found that the correction to be applied on the range scale will be very close to + 207 for a gun on a height of site of 200 feet.

The latest range correction charts for capped projectiles are computed in a like manner, excepting that the $\Delta\varphi$ is applied to $\varphi_\epsilon$ to determine the range setting.

For a given variation from range table conditions, the $\Delta R$ to be applied on the range scale will vary with the height of site, because the relation between $R$ and $\varphi_x$, or $\varphi_\epsilon$, varies as the height of site varies.

In other words, the same elevation or $R$-$\varphi_x$ tables will not do for 12-inch guns and long pointed projectiles for all heights of site; nor for 12-inch guns and capped projectiles for all heights of site; nor for long pointed projectiles and capped projectiles for any height of site. And, because we apply $\Delta\varphi$ to $\varphi_x$ or $\varphi_\epsilon$ to interpolate for the new range setting, the change in range setting, $\Delta R$, will vary with variations in height of site.

Finally, this $\Delta R$ at the range scale is a reference number which secures a proper change in $\varphi_x$ or $\varphi_\epsilon$ by changing the range setting. Adding 200 yards to the range setting may be expected to increase the range of the shot by 200 yards only under normal conditions. Where the $V$ or $C$ varies from normal, the range correction on the range board will give for any range the range correction reference number which, when applied at the range scale, will produce the proper change in the angle of departure.

### *Probelm 12*

Given: 12-inch gun and long-pointed projectile; range to target 8500 yards; $V$, 2250; $C$, 11.7945; height of site, 200 feet; atmosphere reference number, 20.

What is the required range correction reference number?

An atmosphere reference number of 16 represents a normal atmosphere. Under the conditions, there is an increase of $20-16=4\%$ in the ballistic coefficient due to atmospheric conditions as determined by the barometer, thermometer, and atmospheric slide rule.

$$\begin{aligned} \log C &= 1.07168 \\ \log 104\% &= \underline{0.01703} \\ \log C_1 &= 1.08871, \end{aligned}$$

for the day, the actual value we have to work with under the conditions.

$$Z=\frac{X}{C_1}.$$

$$\begin{aligned} \log X &= 4.40654 \\ \operatorname{colog} C_1 &= \underline{8.91129-10} \\ \log Z &= 3.31783 \\ Z &= 2079 \end{aligned}$$

$$\sin 2\varphi' = AC$$

$$(V=2250; Z=2079) \qquad A=.01513+91\times\frac{79}{100}=.01585$$

$$\begin{aligned} \log A &= 8.20003-10 \\ \log C_1 &= \underline{1.08871} \\ \log \sin 2\varphi' &= 9.28874-10 \\ 2\varphi' &= 11^\circ\ 12'.7 \\ \varphi' &= 5^\circ\ 36'.3 \end{aligned}$$

2. From the range table, for 8500 yards, $\varphi=5^\circ\ 39'.2$.
3. $\Delta\varphi=\varphi'-\varphi=5^\circ\ 36'.3-5^\circ\ 39'.2=-2'.9$.
4. Referring to our $R$-$\varphi_x$ table, we see that the quadrant angle of departure, $\varphi_x$, for 8500 yards is 5° 09'.4.
5. $\varphi_x'=\varphi_x+\Delta\varphi=5^\circ\ 09'.4+(-2'.9)=5^\circ\ 06'.5$.
6. Referring to our $R$-$\varphi_x$ table, we see that a quadrant angle of departure of 5° 06'.5 corresponds to a range setting of

$$8440-\frac{06.5-06.3}{07.3-06.3}\times 20=8444$$

7. Therefore the range correction reference number which will secure the proper change in the quadrant angle of departure is

$$\Delta R=8444-8500=-56$$

### *Problem 13*

Given: 12-inch gun and long pointed projectile; range to target, 8500 yards; $C$, 11.7945; $V$, 2250; wind range component reference number, 80; height of site, 200 feet.

What is the required range correction reference number?

A range component reference number of 50 denotes that either the direction of the wind with reference to the line of fire is 90°, or that the wind has 0 velocity; in either case there is little or no movement of the atmosphere parallel to the line joining gun and target.

Therefore $80-50=30$ miles per hour velocity of wind against the motion of the projectile.

The effect of the wind is to decrease the value of the ballistic coefficient.

$$f_w = 1 \pm \frac{2W_x T^{5/4}}{X}$$

$$\begin{aligned}
(\log T = \log 13.11 &= 1.11760) \\
5/4 \log T &= 1.39700 \\
\log 2W_x = \log 60 &= 1.77815 \\
\operatorname{colog} X &= \underline{5.59346-10} \\
\log 0.0587 &= 8.76861-10
\end{aligned}$$

Since it is a head wind,

$f_w = 1 - .059 = .9413 = .94$

$$\begin{aligned}
\log C &= 1.07168 \\
\log 0.94 &= \underline{9.97313-10} \\
\log C_1 &= 1.04481
\end{aligned}$$

$$Z = \frac{X}{C_1}$$

$$\begin{aligned}
\log X &= 4.40654 \\
\operatorname{colog} C_1 &= \underline{8.95519-10} \\
\log Z &= 3.36173 \\
Z &= 2300
\end{aligned}$$

$\sin 2\varphi' = AC$

$(V = 2250;\ Z = 2300)$ $\quad A = .01790$

$$\begin{aligned}
\log A &= 8.25285-10 \\
\log C_1 &= \underline{1.04481} \\
\log \sin 2\varphi' &= 9.29766-10 \\
2\varphi' &= 11^\circ\ 26'.8 \\
\varphi' &= 5^\circ\ 43'.4
\end{aligned}$$

$$\Delta\varphi = \varphi' - \varphi = 5^\circ\ 43'.4 - 5^\circ\ 39'.2 = 4'.2.$$
$$\varphi_x' = \varphi_x + \Delta\varphi = 5^\circ\ 09'.4 + 4'.2 = 5^\circ\ 13'.6.$$

The range setting corresponding to an angle of departure of 5° 13'.6 is, from our $R$-$\varphi_x$ table, 8580.

Therefore the $\Delta R$ to be applied to the range scale to produce the proper change in the angle of departure is

$$\Delta R = 8580 - 8500 = +80$$

### *Problem 14*

Given: a 12-inch gun and long pointed projectile; range to target 8500 yards; $C$, 11.7945; $V$, 2250; tide, + 10 feet; height of site, 200 feet.

What is the required range correction reference number?

Since the basic condition is mean low water, we must determine how much to increase the angle of departure so as to raise the point struck 10 feet.

$$\tan \Delta\varphi = \frac{10}{X}$$

$$\begin{aligned} \log 10 &= 1.00000 \\ \text{colog } X &= 5.59346-10 \\ \hline \log \tan \Delta\varphi &= 6.59346-10 \\ \Delta\varphi &= 1'.4 \end{aligned}$$

$$\varphi'_x = \varphi_x + \Delta\varphi = 5^\circ\ 09'.4 + 1'.4 = 5^\circ\ 10'.8$$

The range setting giving an angle of departure of 5° 10'.8 is

$$8520 + 20 \times \frac{.4}{1.1} = 8527$$

The range correction reference number is, therefore,

$$8527 - 8500 = +27$$

Problems 11 to 14 inclusive illustrate how range correction reference numbers are computed for a particular height of site. For a range correction chart the computations are made for every 1000 yards within the limits of quadrant elevation permitted by the carriage, and for each of the following variations from range table conditions:

(a) Denote the normal velocity by $NV$:
$NV-200$ $NV-100$ $NV$ $NV+100$ $NV+200$
(b) For atmosphere:
0 8 16 24 32
(c) For wind:
10 30 50 70 90
(d) For tide:
−10 0 +10 +20 +30 +40

### Problem 13

Given: 12-inch gun and long poi
target, 8500 yards; *C*, 11.7945; V, 225
reference number, 80; height of site,

What is the required range cor

A range component reference
either the direction of the wind
fire is 90°, or that the wind has 0
is little or no movement of the a
joining gun and target.

Therefore 80 − 50 = 30 mi
against the motion of the pro

The effect of the wind
ballistic coefficient.

$$f_w = 1 \pm$$

$$(\log T = \text{lo}$$

$$5$$

$$\log 2W$$

Since it is a

$f_w = 1 -$

Z

$$5-8500=+225$$

range setting of +214 will change the
shot by +225 yards.

## NS FOR MUZZLE VELOCITY

gun and long pointed projectile; range
8500 yards; range table value of $C$,
reference number, 20; wind reference
+10; range to the center of impact, 8200
ite, 200 feet.
muzzle velocity?

### SOLUTION I

ngle of departure.
of departure is resolved into two parts: (1) the
le of departure, $\varphi'_x$, or that part above the hori-
through the trunnions; and (2) the angle of de-
responding to the range to the center of impact,
ion below the horizontal plane.
ng to problems 11 to 14, we see that the net range
reference number given by the range board is

$$214-56+80+27+(2000)=+265\ (2265)$$

uit our condition to mean low tide, for which our
n and $R$-$\varphi_x$ tables are computed, we can consider our
orrection *reference number* to be 265−27 (the tide cor-
) = 238, and can consider that the range to the center
pact would have been 8200 at mean low water, had the
correction reference number been 2238 instead of 2265.
The corrected range becomes 8500+238 = 8738.

$\varphi_x'$ corresponding to a range setting of 8738 is 5° 21'.8.

Also, from the $R-\varphi_x$ table, we see that the depression
ngle for the range to the center of impact is 30'.7.

Therefore,

$$\varphi'=5^\circ\ 21'.8+30'.7=5^\circ\ 52'.5$$

From problems 12 and 13.

$$C_1=f_w\times\frac{\delta_1}{\delta}\times C=1.04\times 0.94\times C$$

$$\begin{aligned}\log C &= 1.07168\\ \log 1.04 &= 0.01703\\ \log 0.94 &= 9.97313-10\\ \hline \log C_1 &= 1.06184\end{aligned}$$

$$Z = \frac{X}{C_1}$$

$$\begin{aligned} \log X = \log (3 \times 8200) &= 4.39093 \\ \operatorname{colog} C_1 &= \underline{8.93816-10} \\ \log Z &= 3.32909 \\ Z &= 2133 \end{aligned}$$

$$A = \frac{\sin 2\varphi'}{C_1}$$

$$\begin{aligned} \log \sin 2\varphi' = \log \sin 11^\circ 45'.0 &= 9.30886-10 \\ \operatorname{colog} C_1 &= \underline{8.93816-10} \\ \log A &= 8.24702-10 \\ A &= 0.01766 \end{aligned}$$

We now enter Table II and determine the consecutive velocities for which, for our value of $Z = 2133$, the values of $A$ bracket our value of $A$. Then we interpolate for the velocity by means of $A$.

$$\begin{array}{llll} Z = 2133 & (V = 2200) & A = 0.01712 & \Delta = 70 \\ & (V = 2150) & A = 0.01782 & \end{array}$$

$$V = 2200 - 50 \times \frac{.01766-.0712}{.00070} = 2200-39 = 2161 \text{ f.s.}$$

NOTE: If a range correction chart is at hand, the percentage change in $C$ effected by the wind can be determined quickly, as follows, without use of the wind formula: Hold the straight edge of a piece of paper parallel to the range lines and at the range of the aiming point. Graduate the edge where it is intersected by the normal (50) and letter the mark O. Graduate the edge where the wind curve (or interpolated imaginary curve) cuts the edge. Letter the graduation K. Transfer the paper parallel to the range lines until the O graduation is over the normal atmosphere curve (16). The K graduation now indicates the equivalent change in $C$ in terms of an atmosphere reference number, whence the percentage change is determined by remembering that 16 is 1.00, 18 is 1.02, 14 is .98, etc.

If the chart is mounted on a range board, the operation may be performed with the ruler.

### SOLUTION II

In this case, consider that the change in the ballistic coefficient due to atmosphere and wind is compensated for by their portions of the total range correction reference number. Then assume $C$ as normal, and consider only the range correction reference number due to velocity.

From Problem 11, we see that in the operation of the range board we should have secured a range correction reference number of + 214 (2214) for an assumed velocity of 2215 for the trial shots.

Consulting our $R$-$\varphi_x$ table, we see that the quadrant angle of departure for a range setting of (8500+214 =) 8714 is

$$\varphi'_x = 5^\circ\, 20'.5$$

The depression angle corresponding to the center of impact is 30'.7.

Therefore,

$$\varphi' = 5^\circ\, 20'.5 + 30'.7 = 5^\circ\, 51'.2$$

$$Z = \frac{X}{C}$$

$$\begin{aligned} \log X = \log (3 \times 8200) &= 4.39093 \\ \text{colog}\, C &= \underline{8.92832 - 10} \\ \log Z &= 3.31925 \\ Z &= 2086 \end{aligned}$$

$$A = \frac{\sin 2\varphi'}{C}$$

$$\begin{aligned} \log \sin 2\varphi' = \log \sin 11^\circ\, 42'.4 &= 9.30728 - 10 \\ \text{colog}\, C &= \underline{8.92832 - 10} \\ \log A &= 8.23560 - 10 \\ A &= 0.01720 \end{aligned}$$

We now enter Table II and determine the consecutive velocities for which, for our value of $Z = 2086$, the values of $A$ bracket our value of $A$. Then we interpolate for $V$ by means of $A$.

$$Z = 2086 \qquad (V = 2200) \quad A = 0.01667 \qquad \Delta = 68$$

$$(V = 2150) \quad A = 0.01735$$

$$V = 2200 - 50 \times \frac{.01720 - .01667}{.00068} = 2200 - 39 = 2161 \text{ f.s.}$$

For capped projectiles the solutions are analogous, excepting that $\varphi' = \varphi'_\epsilon$ (for the corrected range) + $\epsilon$ (corresponding to the range to the center of impact).

Velocity graphic charts are issued for the same limits of height as the range correction charts, for a given caliber of gun, projectile, and normal muzzle velocity.

In case the proper velocity graphic chart is not at hand, one can be readily constructed as follows:

1. Select the aiming point for the trial shots and determine its range.
2. Determine the muzzle velocity to be assumed for trial shots.
3. Assume centers of impact at 100 yard intervals over and short, within limits of about ± 500 yards.
4. Compute and tabulate the velocities corresponding to such rangings.
5. On cross-section paper, with the X axis for range and the Y axis for velocities, plot these points and connect them by a smooth curve.

### Deflections

The deflection problem is briefly as follows (see Fig. 9):

Assume a target at $T$ moving at such a rate in the direction shown by the arrow that it will be at $T_1$ at the end of the time of flight for the range $GT$. It is obvious we must incline the plane of departure to the plane of sight by the angle *1* to correct for the angular movement of the target during the time of flight.

Assume that, due to drift alone, at this range, the point of impact would fall in the direction of $T_2$ instead of $T$. It is obvious that we must increase the angle *1* by the angle *2* to correct for drift also.

Assume that the wind would blow the projectile so as to cause the point of impact to be in the direction of $T_3$ instead of $T$. It is obvious that we must increase angle *1* by the angle *3* to correct for the effect of the wind as well.

Therefore, the net angular correction for travel during time of flight, drift, and the lateral wind component is the angle $4 (= 1 + 2 + 3)$.

Then, if the plane of departure is inclined to the plane of sight by the angle *4* as set off on the sight, the projectile will depart from the plane $GT_4$ under the action of wind and drift and will strike in the direction of the point $T_1$, the direction of the target at the end of the time of flight.

For simplicity, the figure is drawn showing the conditions to require cumulative corrections.

In Cases I and II the required divergence of the plane of departure from the plane of sight is secured by means of the deflection set off on the sight.

In Case III, the angle *4* is applied to the uncorrected azimuth of the line $GT$ in order to obtain the corrected azimuth $GT_4$ at which to lay the piece. This applies to both guns and mortars. A study at the deflection board will illustrate how these corrections are automatically added.

On a gun deflection board note that:

(a) The drift leaf is only for certain projectiles, caliber, and muzzle velocity.

(b) The scale on the T square is not equicrescent and the ranges are graduated in proportion to their times of flight, and therefore the T square is only for certain projectiles, caliber, and muzzle velocity.

Rules for Deflection corrections:

R–R. Right-Raise. To shoot more to the Right, Raise the value of the deflection or corrected azimuth by the desired amount.

If the shots are falling 0°.10 to the left of the target, Raise the value of the deflection or corrected azimuth 0°.10 in order to shoot 0°.10 more to the Right.

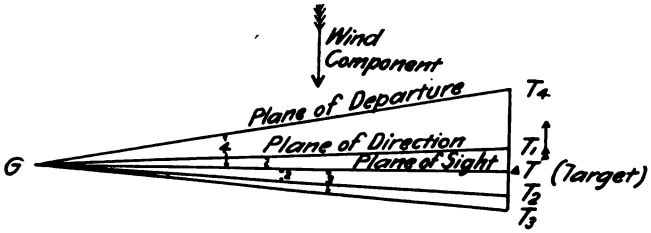


FIG. 9.

L–L. Left-Lower. To shoot more to the Left, Lower the value of the deflection or corrected azimuth by the desired amount.

If the shots are falling 0°.15 to the right of the target, Lower the value of the deflection or corrected azimuth 0°.15 in order to shoot 0°.15 more to the Left.

To avoid confusion and errors in applying corrections, the corrected deflection, not the correction, should be transmitted.

The smallest division on the sight is 0°.05. The natural tangent of 0°.05 (=3′) is approximately 1/1000, but the true value to sufficient accuracy is .00087.

The latter value should be used for computing deviations in yards from observed angular deviations.

The approximate value of .001 is of interest in making quick computations. 1 division = 1 yard per thousand of range.

*Example*

A battleship is head-on at 8000 yards. The shots seem to fall consistently about half the width of the target to the right. Deflection, 2.80.

Solution:

One width from the center of the target equals about 90 feet = 30 yards.

One division on sight at 8000 yards = 8000 × .001 = 8 yds.

30 ÷ 8 = 4 divisions.

Correction = 4 × .05 = 0°.20

To shoot Left—Lower. Corrected deflection = 2.80 − .20 = 2.60

### DIFFERENTIAL FORMULÆ

Occasionally it is desirable to know how much of a range error is to be expected from a variation from normal, either in the weight of the projectile, or of the charge, or both. The following formulæ are fairly accurate for small variations from standard conditions.

*Variation in muzzle velocity due to a variation in weight of projectile:*

$$\Delta V = -\frac{7}{16}\frac{\Delta w}{w}V$$

*Problem 16*

An officer is to fire long pointed projectiles from his 12-inch battery for the first time. Previous firings with the same weight of powder and capped (1046-lb.) projectiles indicate that for the temperature of 70° F., the M.V. assumed should be 2220 f.s. About what M.V. will be given to the long pointed projectiles weighing 1070 lbs.?

$$V = -\frac{7}{16} \times \frac{24}{1046} \times 2220 = -22 \text{ f.s.}$$

The result indicates that he should assume about 2200 f.s.

*Problem 17*

A battery commander is to fire long pointed projectiles from his 12-inch battery for the first time. Previous firings with the weights of powder as made up into charges, and using capped (1046-lb.) projectiles, indicate that at a temperature of 70°F. the M.V. to be assumed is 2220 f.s. Each charge as made up weighs 276.5 lbs. About what weight of nitro-celhould be added to each charge to give the nor-

blem 16 the M.V. will probably be approxi-
. at 70° F.

ty to be expected due to changes in the weight
rges may be computed from the formula,

$$\left(\frac{w}{w_1}\right)^y \quad \text{(See C.A.D.R., 1909, par 796.)}$$

rage value of $y$ is: for nitro-cellulose powder, 1.2;
cerin powder, 0.8.

re,

$$\frac{2200}{2250} = \left(\frac{276.5}{w_1}\right)^{1.2}$$

$$w_1^{1.2} = \frac{2250 \times 276.5^{1.2}}{2200}$$

$$\begin{aligned}
\log 2250 &= 3.35218 \\
1.2 \log 276.5 &= 2.93003 \\
\operatorname{colog} 2200 &= \underline{6.65758 - 10} \\
1.2 \log w_1 &= 2.93979 \\
\log w_1 &= 2.44982 \\
w_1 &= 281.7 \text{ lbs.} = \text{what each charge}
\end{aligned}$$

d weigh.

281.7 − 276.5 = 5.2 pounds to be added to each charge.

*Variation in muzzle velocity due to a variation in the travel he shot while in the bore:*

$$\Delta V = \frac{3}{16} \frac{\Delta u}{u} V$$

In which $u$ = travel of shot. $\Delta u$ = variation in travel f shot.

*Variation in muzzle velocity due to variation in size of chamber:*

$$\Delta V = \frac{1}{4} \frac{\Delta v}{v} V$$

In which $v$ = volume of chamber. $\Delta v$ = variation in volume of chamber.

*Variation in muzzle velocity due to a variation in caliber:*

$$\Delta V = \frac{1}{8} \frac{\Delta d}{d} V$$

In which $d$ = caliber. $\Delta d$ = variation in caliber.

In American guns the weight of projectile and charge should be taken in pounds, the length of travel and caliber in

npensate for gun displacement. Connect these points by
. Letter this curve "Displacement Correction."
raw the *net correction curve* by combining the level and
rrections.
nd that at Battery Eustis the net correction curve is sensi-
the X-axis, which permitted a flat correction to be applied
e elevation pointer.

l be noted that where a flat correction cannot be
ith sufficient accuracy, the pointer can be shifted
nsate for the correction obtaining in the most im-
art of the field of fire. On the basis of this shift, the
corrections for other azimuths can be determined and
as heretofore, thus reducing the amount of the cor-
to be applied at the range scale. In some cases it may
ed advisable so to shift the pointer that all corrections
e of a positive value, thus eliminating the necessity of
ng now a positive correction, and at another time a
ve correction.

### II. CORRECTION TO ADJUST THE CENTER OF IMPACT TO THE CENTER OF THE 1914 RECORD TARGET

1. The danger space in yards = 10 cot $(\omega + \epsilon)$.

2. The number of yards to be added $= \dfrac{\text{D. S.} + 15 - 25}{2}$.

Plot these values as determined for every 2000 yards from 3000 to
00 yards; scale: X-axis, 1" = 1000 yards; Y-axis, 1" = 20 yards. Con-
t these points by a smooth curve. This chart was found convenient
plotting the target for the determination of hits.

These corrections vary with the range. They are incorrect for applica-
on as a range correction until the $\Delta\varphi$ corresponding thereto is determined
rom the range table. With this $\Delta\varphi$ as an argument, the $\Delta R$ to be applied
t the range scale is determined from the $R$-$\varphi_x$, or $R$-$\varphi_\epsilon$, table for the
battery.

3. The correction expressed in feet of tide is,

$$\Delta R_t = 3 \times \text{correction in yards} \times \tan(\omega + \epsilon)$$

4. To adjust the center of impact to the center of the record target, a chart was made showing the above corrections expressed in feet of tide, by plotting the corrections for every 3000 yards from zero to 11,000 yards and connecting the points by a smooth curve.

It was seen that a flat correction could be made by the tide curve for target practice ranges without material error. For Battery Eustis the correction was about 13 feet of tide.

It will be observed that the greater tide curves on the latest range correction charts were plotted up to + 40 feet of tide for this purpose, and to meet the service condition in placing the center of impact at the desired point on a hostile target.

The 1914 record target is described in the *Regulations for the Instruction and Target Practice of Coast Artillery Troops, 1914* as follows:

> 123. *Record Target for Major and Intermediate Caliber Guns.*—Using a piece of cross-section paper at a scale of 50 yards to the inch, consider one of the heavy lines as the track of the target and the intersection of the two heavy lines as the location of the towed target. On the track of the target lay off the length of the towline and plot the position of the tug. Draw a line of direction through the center of the target and the directing point of the battery. Draw two lines parallel to and 15 yards from the track of the target. Similarly, draw two lines parallel to and 15 yards from the line of direction. The parallelogram so formed is the horizontal projection of a section of a battleship, and is part of the record target. To complete the record target extend the sides of this parallelogram 10 yards toward the battery and the length of the danger space away from the battery, assuming the freeboard of a battleship as 30 feet. This completed parallelogram is the record target.

## TABLE A

Values of $\delta_1/\delta$ for temperature and pressure of atmosphere 78% saturated with moisture. (From *Artillery Note No. 25.*)

| Ther. | Barometer | | | | Ther. | Barometer | | | |
|---|---|---|---|---|---|---|---|---|---|
| F. | 28″ | 29″ | 30″ | 31″ | F. | 28″ | 29″ | 30″ | 31″ |
| —20° | 0.890 | 0.861 | 0.831 | 0.806 | 5° | 0.942 | 0.909 | 0.880 | 0.851 |
| —19° | 0.892 | 0.863 | 0.833 | 0.808 | 6° | 0.944 | 0.911 | 0.881 | 0.853 |
| —18° | 0.894 | 0.864 | 0.835 | 0.809 | 7° | 0.946 | 0.913 | 0.883 | 0.855 |
| —17° | 0.896 | 0.866 | 0.837 | 0.811 | 8° | 0.948 | 0.915 | 0.885 | 0.856 |
| —16° | 0.898 | 0.868 | 0.839 | 0.813 | 9° | 0.950 | 0.917 | 0.887 | 0.858 |
| —15° | 0.901 | 0.870 | 0.841 | 0.815 | 10° | 0.952 | 0.919 | 0.889 | 0.860 |
| —14° | 0.903 | 0.872 | 0.843 | 0.816 | 11° | 0.954 | 0.921 | 0.890 | 0.862 |
| —13° | 0.905 | 0.874 | 0.845 | 0.818 | 12° | 0.956 | 0.923 | 0.892 | 0.864 |
| —12° | 0.907 | 0.876 | 0.847 | 0.820 | 13° | 0.958 | 0.925 | 0.894 | 0.866 |
| —11° | 0.910 | 0.878 | 0.848 | 0.822 | 14° | 0.960 | 0.927 | 0.897 | 0.867 |
| —10° | 0.912 | 0.880 | 0.850 | 0.824 | 15° | 0.962 | 0.929 | 0.899 | 0.869 |
| — 9° | 0.914 | 0.881 | 0.852 | 0.826 | 16° | 0.964 | 0.931 | 0.901 | 0.871 |
| — 8° | 0.916 | 0.883 | 0.854 | 0.827 | 17° | 0.966 | 0.933 | 0.903 | 0.873 |
| — 7° | 0.918 | 0.885 | 0.856 | 0.829 | 18° | 0.968 | 0.935 | 0.905 | 0.875 |
| — 6° | 0.920 | 0.887 | 0.858 | 0.831 | 19° | 0.971 | 0.937 | 0.907 | 0.877 |
| — 5° | 0.922 | 0.889 | 0.860 | 0.833 | 20° | 0.973 | 0.939 | 0.909 | 0.879 |
| — 4° | 0.924 | 0.891 | 0.862 | 0.835 | 21° | 0.975 | 0.941 | 0.911 | 0.881 |
| — 3° | 0.926 | 0.893 | 0.864 | 0.836 | 22° | 0.977 | 0.943 | 0.912 | 0.883 |
| — 2° | 0.928 | 0.895 | 0.866 | 0.838 | 23° | 0.979 | 0.945 | 0.914 | 0.885 |
| — 1° | 0.930 | 0.897 | 0.868 | 0.840 | 24° | 0.981 | 0.947 | 0.916 | 0.887 |
| 0° | 0.932 | 0.899 | 0.870 | 0.842 | 25° | 0.983 | 0.949 | 0.918 | 0.888 |
| 1° | 0.934 | 0.901 | 0.871 | 0.844 | 26° | 0.985 | 0.951 | 0.920 | 0.890 |
| 2° | 0.936 | 0.903 | 0.873 | 0.845 | 27° | 0.987 | 0.953 | 0.922 | 0.892 |
| 3° | 0.938 | 0.905 | 0.876 | 0.847 | 28° | 0.990 | 0.955 | 0.924 | 0.894 |
| 4° | 0.940 | 0.907 | 0.878 | 0.849 | 29° | 0.992 | 0.958 | 0.926 | 0.896 |

## TABLE A—Continued.

| Ther. F. | Barometer 28″ | 29″ | 30″ | 31″ | Ther. F. | Barometer 28″ | 29″ | 30″ | 31″ |
|---|---|---|---|---|---|---|---|---|---|
| 30° | 0.994 | 0.960 | 0.928 | 0.898 | 66° | 1.073 | 1.035 | 1.001 | 0.968 |
| 31° | 0.996 | 0.962 | 0.930 | 0.899 | 67° | 1.075 | 1.037 | 1.003 | 0.970 |
| 32° | 0.998 | 0.964 | 0.932 | 0.902 | 68° | 1.078 | 1.040 | 1.005 | 0.973 |
| 33° | 1.000 | 0.966 | 0.934 | 0.903 | 69° | 1.080 | 1.042 | 1.007 | 0.975 |
| 34° | 1.003 | 0.968 | 0.936 | 0.906 | 70° | 1.082 | 1.044 | 1.009 | 0.977 |
| 35° | 1.005 | 0.970 | 0.938 | 0.907 | 71° | 1.085 | 1.046 | 1.011 | 0.979 |
| 36° | 1.007 | 0.972 | 0.940 | 0.909 | 72° | 1.087 | 1.048 | 1.013 | 0.981 |
| 37° | 1.009 | 0.974 | 0.943 | 0.911 | 73° | 1.089 | 1.050 | 1.015 | 0.983 |
| 38° | 1.011 | 0.976 | 0.945 | 0.913 | 74° | 1.092 | 1.053 | 1.017 | 0.985 |
| 39° | 1.013 | 0.978 | 0.947 | 0.915 | 75° | 1.094 | 1.055 | 1.019 | 0.987 |
| 40° | 1.015 | 0.980 | 0.949 | 0.917 | 76° | 1.096 | 1.057 | 1.022 | 0.989 |
| 41° | 1.017 | 0.982 | 0.951 | 0.919 | 77° | 1.099 | 1.059 | 1.025 | 0.992 |
| 42° | 1.019 | 0.984 | 0.953 | 0.921 | 78° | 1.101 | 1.062 | 1.027 | 0.994 |
| 43° | 1.021 | 0.987 | 0.955 | 0.923 | 79° | 1.104 | 1.064 | 1.029 | 0.996 |
| 44° | 1.023 | 0.989 | 0.957 | 0.925 | 80° | 1.106 | 1.066 | 1.031 | 0.998 |
| 45° | 1.026 | 0.991 | 0.959 | 0.927 | 81° | 1.109 | 1.068 | 1.033 | 1.000 |
| 46° | 1.028 | 0.993 | 0.961 | 0.929 | 82° | 1.111 | 1.071 | 1.035 | 1.002 |
| 47° | 1.030 | 0.995 | 0.963 | 0.931 | 83° | 1.114 | 1.074 | 1.038 | 1.005 |
| 48° | 1.033 | 0.997 | 0.964 | 0.933 | 84° | 1.116 | 1.076 | 1.041 | 1.007 |
| 49° | 1.035 | 0.999 | 0.966 | 0.935 | 85° | 1.119 | 1.079 | 1.043 | 1.009 |
| 50° | 1.037 | 1.002 | 0.968 | 0.937 | 86° | 1.121 | 1.081 | 1.045 | 1.011 |
| 51° | 1.040 | 1.004 | 0.970 | 0.939 | 87° | 1.124 | 1.083 | 1.047 | 1.013 |
| 52° | 1.042 | 1.006 | 0.972 | 0.941 | 88° | 1.126 | 1.086 | 1.049 | 1.016 |
| 53° | 1.044 | 1.008 | 0.974 | 0.943 | 89° | 1.129 | 1.089 | 1.053 | 1.018 |
| 54° | 1.046 | 1.010 | 0.976 | 0.945 | 90° | 1.131 | 1.092 | 1.055 | 1.020 |
| 55° | 1.048 | 1.012 | 0.978 | 0.947 | 91° | 1.134 | 1.094 | 1.057 | 1.022 |
| 56° | 1.050 | 1.014 | 0.980 | 0.949 | 92° | 1.136 | 1.096 | 1.059 | 1.025 |
| 57° | 1.053 | 1.016 | 0.982 | 0.951 | 93° | 1.139 | 1.099 | 1.062 | 1.027 |
| 58° | 1.055 | 1.018 | 0.984 | 0.952 | 94° | 1.142 | 1.102 | 1.064 | 1.029 |
| 59° | 1.057 | 1.020 | 0.986 | 0.954 | 95° | 1.144 | 1.105 | 1.066 | 1.031 |
| 60° | 1.059 | 1.022 | 0.988 | 0.956 | 96° | 1.147 | 1.107 | 1.068 | 1.033 |
| 61° | 1.062 | 1.025 | 0.990 | 0.958 | 97° | 1.149 | 1.110 | 1.071 | 1.035 |
| 62° | 1.064 | 1.027 | 0.992 | 0.960 | 98° | 1.152 | 1.112 | 1.074 | 1.037 |
| 63° | 1.066 | 1.029 | 0.994 | 0.962 | 99° | 1.155 | 1.115 | 1.076 | 1.040 |
| 64° | 1.068 | 1.013 | 0.996 | 0.964 | 100° | 1.157 | 1.117 | 1.079 | 1.042 |
| 65° | 1.071 | 1.033 | 0.998 | 0.966 | | | | | |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2000$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1389 | 34 | 1236 | 14 | 2.378 | 81 | 5.0569 | 44 |
| 3800 | 0.1423 | 35 | 1222 | 13 | 2.459 | 83 | 5.0613 | 44 |
| 3900 | 0.1458 | 34 | 1209 | 13 | 2.542 | 83 | 5.0657 | 44 |
| 4000 | 0.1492 | 33 | 1196 | 12 | 2.625 | 84 | 5.0701 | 45 |
| 4100 | 0.1525 | 32 | 1184 | 12 | 2.709 | 85 | 5.0746 | 45 |
| 4200 | 0.1557 | 30 | 1172 | 12 | 2.794 | 86 | 5.0791 | 45 |
| 4300 | 0.1587 | 30 | 1160 | 11 | 2.880 | 87 | 5.0836 | 45 |
| 4400 | 0.1617 | 28 | 1149 | 11 | 2.967 | 87 | 5.0881 | 44 |
| 4500 | 0.1645 | 28 | 1138 | 11 | 3.054 | 88 | 5.0925 | 45 |
| 4600 | 0.1673 | 26 | 1127 | 10 | 3.142 | 89 | 5.0970 | 44 |
| 4700 | 0.1699 | 25 | 1117 | 10 | 3.231 | 90 | 5.1014 | 44 |
| 4800 | 0.1724 | 25 | 1107 | 9 | 3.321 | 91 | 5.1058 | 43 |
| 4900 | 0.1749 | 23 | 1098 | 9 | 3.412 | 91 | 5.1101 | 44 |
| 5000 | 0.1772 | 23 | 1089 | 9 | 3.503 | 92 | 5.1145 | 44 |
| 5100 | 0.1795 | 22 | 1080 | 8 | 3.595 | 93 | 5.1189 | 43 |
| 5200 | 0.1817 | 21 | 1072 | 8 | 3.688 | 94 | 5.1232 | 44 |
| 5300 | 0.1838 | 20 | 1064 | 8 | 3.782 | 94 | 5.1276 | 43 |
| 5400 | 0.1858 | 19 | 1056 | 8 | 3.876 | 95 | 5.1319 | 42 |
| 5500 | 0.1877 | 18 | 1048 | 8 | 3.971 | 96 | 5.1361 | 43 |
| 5600 | 0.1895 | 18 | 1040 | 7 | 4.067 | 97 | 5.1404 | 42 |
| 5700 | 0.1913 | 17 | 1033 | 7 | 4.164 | 97 | 5.1446 | 42 |
| 5800 | 0.1930 | 16 | 1026 | 7 | 4.261 | 98 | 5.1488 | 42 |
| 5900 | 0.1946 | 16 | 1019 | 7 | 4.359 | 98 | 5.1530 | 41 |
| 6000 | 0.1962 | 15 | 1012 | 6 | 4.457 | 99 | 5.1571 | 41 |
| 6100 | 0.1977 | 14 | 1006 | 7 | 4.556 | 100 | 5.1612 | 41 |
| 6200 | 0.1991 | 14 | 999 | 6 | 4.656 | 100 | 5.1653 | 40 |
| 6300 | 0.2005 | 13 | 993 | 6 | 4.756 | 101 | 5.1693 | 40 |
| 6400 | 0.2018 | 13 | 987 | 6 | 4.857 | 102 | 5.1733 | 40 |
| 6500 | 0.2031 | 12 | 981 | 5 | 4.959 | 102 | 5.1773 | 40 |
| 6600 | 0.2043 | 12 | 976 | 6 | 5.061 | 103 | 5.1813 | 40 |
| 6700 | 0.2055 | 11 | 970 | 6 | 5.164 | 103 | 5.1853 | 39 |
| 6800 | 0.2066 | 11 | 964 | 6 | 5.267 | 104 | 5.1892 | 39 |
| 6900 | 0.2077 | 11 | 958 | 5 | 5.371 | 105 | 5.1931 | 38 |
| 7000 | 0.2088 | 13 | 953 | 5 | 5.476 | 105 | 5.1969 | 38 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2100$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1397 | 35 | 1297 | 16 | 2.262 | 78 | 5.0132 | 44 |
| 3800 | 0.1432 | 35 | 1281 | 15 | 2.340 | 78 | 5.0176 | 45 |
| 3900 | 0.1467 | 35 | 1266 | 15 | 2.418 | 80 | 5.0221 | 45 |
| 4000 | 0.1502 | 34 | 1251 | 15 | 2.498 | 81 | 5.0266 | 45 |
| 4100 | 0.1536 | 34 | 1236 | 14 | 2.579 | 81 | 5.0311 | 45 |
| 4200 | 0.1570 | 34 | 1222 | 13 | 2.660 | 82 | 5.0356 | 45 |
| 4300 | 0.1604 | 34 | 1209 | 13 | 2.742 | 83 | 5.0401 | 45 |
| 4400 | 0.1638 | 33 | 1196 | 13 | 2.825 | 84 | 5.0446 | 45 |
| 4500 | 0.1671 | 32 | 1183 | 12 | 2.909 | 85 | 5.0491 | 45 |
| 4600 | 0.1703 | 30 | 1171 | 12 | 2.994 | 86 | 5.0536 | 45 |
| 4700 | 0.1733 | 29 | 1159 | 12 | 3.080 | 87 | 5.0581 | 45 |
| 4800 | 0.1762 | 28 | 1147 | 11 | 3.167 | 87 | 5.0626 | 46 |
| 4900 | 0.1790 | 28 | 1136 | 10 | 3.254 | 89 | 5.0672 | 45 |
| 5000 | 0.1818 | 26 | 1126 | 10 | 3.343 | 89 | 5.0717 | 46 |
| 5100 | 0.1844 | 24 | 1116 | 10 | 3.432 | 91 | 5.0763 | 45 |
| 5200 | 0.1868 | 24 | 1106 | 9 | 3.523 | 91 | 5.0808 | 45 |
| 5300 | 0.1892 | 24 | 1097 | 9 | 3.614 | 92 | 5.0853 | 45 |
| 5400 | 0.1916 | 23 | 1088 | 9 | 3.706 | 92 | 5.0898 | 45 |
| 5500 | 0.1939 | 22 | 1079 | 8 | 3.798 | 93 | 5.0943 | 44 |
| 5600 | 0.1961 | 21 | 1071 | 9 | 3.891 | 94 | 5.0987 | 44 |
| 5700 | 0.1982 | 20 | 1062 | 8 | 3.985 | 94 | 5.1031 | 44 |
| 5800 | 0.2002 | 20 | 1054 | 8 | 4.079 | 95 | 5.1075 | 44 |
| 5900 | 0.2022 | 19 | 1046 | 7 | 4.174 | 96 | 5.1119 | 43 |
| 6000 | 0.2041 | 17 | 1039 | 7 | 4.270 | 97 | 5.1162 | 43 |
| 6100 | 0.2058 | 16 | 1032 | 7 | 4.367 | 97 | 5.1205 | 43 |
| 6200 | 0.2074 | 16 | 1025 | 7 | 4.464 | 98 | 5.1248 | 43 |
| 6300 | 0.2090 | 15 | 1018 | 6 | 4.562 | 99 | 5.1291 | 42 |
| 6400 | 0.2105 | 15 | 1012 | 7 | 4.661 | 99 | 5.1333 | 42 |
| 6500 | 0.2120 | 14 | 1005 | 6 | 4.760 | 100 | 5.1375 | 42 |
| 6600 | 0.2134 | 14 | 999 | 7 | 4.860 | 100 | 5.1417 | 42 |
| 6700 | 0.2148 | 14 | 992 | 6 | 4.960 | 101 | 5.1459 | 41 |
| 6800 | 0.2162 | 13 | 986 | 6 | 5.061 | 102 | 5.1500 | 41 |
| 6900 | 0.2175 | 12 | 980 | 6 | 5.163 | 102 | 5.1541 | 41 |
| 7000 | 0.2187 | 11 | 974 | 6 | 5.265 | 103 | 5.1582 | 40 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2200$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 100 | 0.0036 | 36 | 2173 | 27 | 0.046 | 46 | 4.8266 | 35 |
| 200 | 0.0072 | 36 | 2146 | 26 | 0.092 | 47 | 4.8301 | 36 |
| 300 | 0.0108 | 37 | 2120 | 27 | 0.139 | 47 | 4.8337 | 36 |
| 400 | 0.0145 | 36 | 2093 | 26 | 0.186 | 48 | 4.8373 | 36 |
| 500 | 0.0181 | 37 | 2067 | 26 | 0.234 | 49 | 4.8409 | 37 |
| 600 | 0.0218 | 37 | 2041 | 26 | 0.283 | 49 | 4.8446 | 37 |
| 700 | 0.0255 | 37 | 2015 | 25 | 0.332 | 50 | 4.8483 | 37 |
| 800 | 0.0292 | 37 | 1990 | 26 | 0.382 | 51 | 4.8520 | 37 |
| 900 | 0.0329 | 37 | 1964 | 25 | 0.433 | 51 | 4.8557 | 38 |
| 1000 | 0.0366 | 38 | 1939 | 25 | 0.484 | 52 | 4.8595 | 38 |
| 1100 | 0.0404 | 37 | 1914 | 25 | 0.536 | 52 | 4.8633 | 39 |
| 1200 | 0.0441 | 38 | 1889 | 24 | 0.588 | 54 | 4.8672 | 39 |
| 1300 | 0.0479 | 37 | 1865 | 25 | 0.642 | 54 | 4.8711 | 39 |
| 1400 | 0.0516 | 38 | 1840 | 24 | 0.696 | 54 | 4.8750 | 39 |
| 1500 | 0.0554 | 38 | 1816 | 23 | 0.750 | 56 | 4.8789 | 39 |
| 1600 | 0.0592 | 38 | 1793 | 24 | 0.806 | 56 | 4.8828 | 40 |
| 1700 | 0.0630 | 38 | 1769 | 23 | 0.862 | 57 | 4.8868 | 40 |
| 1800 | 0.0668 | 38 | 1746 | 23 | 0.919 | 58 | 4.8908 | 40 |
| 1900 | 0.0706 | 39 | 1723 | 22 | 0.977 | 58 | 4.8948 | 41 |
| 2000 | 0.0745 | 38 | 1701 | 22 | 1.035 | 59 | 4.8989 | 41 |
| 2100 | 0.0783 | 38 | 1679 | 22 | 1.094 | 60 | 4.9030 | 41 |
| 2200 | 0.0821 | 39 | 1657 | 21 | 1.151 | 61 | 4.9071 | 41 |
| 2300 | 0.0860 | 38 | 1636 | 22 | 1.215 | 62 | 4.9112 | 42 |
| 2400 | 0.0898 | 38 | 1614 | 21 | 1.277 | 62 | 4.9154 | 41 |
| 2500 | 0.0936 | 38 | 1593 | 21 | 1.339 | 64 | 4.9195 | 42 |
| 2600 | 0.0974 | 38 | 1572 | 20 | 1.403 | 64 | 4.9237 | 42 |
| 2700 | 0.1012 | 38 | 1552 | 21 | 1.467 | 65 | 4.9279 | 43 |
| 2800 | 0.1050 | 38 | 1531 | 20 | 1.532 | 65 | 4.9322 | 42 |
| 2900 | 0.1088 | 38 | 1511 | 20 | 1.597 | 67 | 4.9364 | 43 |
| 3000 | 0.1126 | 38 | 1491 | 20 | 1.664 | 67 | 4.9407 | 43 |
| 3100 | 0.1164 | 38 | 1471 | 19 | 1.731 | 68 | 4.9450 | 43 |
| 3200 | 0.1202 | 38 | 1452 | 19 | 1.799 | 69 | 4.9493 | 43 |
| 3300 | 0.1240 | 37 | 1433 | 19 | 1.868 | 70 | 4.9536 | 43 |
| 3400 | 0.1277 | 38 | 1414 | 19 | 1.938 | 71 | 4.9579 | 44 |
| 3500 | 0.1315 | 38 | 1395 | 18 | 2.009 | 73 | 4.9623 | 44 |
| 3600 | 0.1353 | 37 | 1377 | 17 | 2.082 | 73 | 4.9667 | 44 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2200$ f.s.

| $\frac{X}{C} = Z$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1390 | 38 | 1360 | 18 | 2.155 | 74 | 4.9711 | 44 |
| 3800 | 0.1428 | 37 | 1342 | 17 | 2.229 | 75 | 4.9755 | 45 |
| 3900 | 0.1465 | 38 | 1325 | 16 | 2.304 | 76 | 4.9800 | 45 |
| 4000 | 0.1503 | 37 | 1309 | 16 | 2.380 | 77 | 4.9845 | 45 |
| 4100 | 0.1540 | 37 | 1293 | 16 | 2.457 | 78 | 4.9890 | 45 |
| 4200 | 0.1577 | 36 | 1277 | 16 | 2.535 | 78 | 4.9935 | 46 |
| 4300 | 0.1613 | 35 | 1261 | 15 | 2.613 | 80 | 4.9981 | 45 |
| 4400 | 0.1648 | 34 | 1246 | 14 | 2.693 | 81 | 5.0026 | 46 |
| 4500 | 0.1682 | 34 | 1232 | 14 | 2.774 | 81 | 5.0072 | 46 |
| 4600 | 0.1716 | 33 | 1218 | 14 | 2.855 | 83 | 5.0118 | 45 |
| 4700 | 0.1749 | 33 | 1204 | 13 | 2.938 | 83 | 5.0163 | 46 |
| 4800 | 0.1782 | 32 | 1191 | 12 | 3.021 | 85 | 5.0209 | 46 |
| 4900 | 0.1814 | 31 | 1179 | 12 | 3.106 | 85 | 5.0255 | 46 |
| 5000 | 0.1845 | 31 | 1167 | 12 | 3.191 | 86 | 5.0301 | 46 |
| 5100 | 0.1876 | 29 | 1155 | 11 | 3.277 | 87 | 5.0347 | 46 |
| 5200 | 0.1905 | 29 | 1144 | 10 | 3.364 | 88 | 5.0393 | 46 |
| 5300 | 0.1934 | 27 | 1134 | 11 | 3.452 | 89 | 5.0439 | 46 |
| 5400 | 0.1961 | 26 | 1123 | 10 | 3.541 | 89 | 5.0485 | 46 |
| 5500 | 0.1987 | 26 | 1113 | 10 | 3.630 | 90 | 5.0531 | 46 |
| 5600 | 0.2013 | 24 | 1103 | 9 | 3.720 | 91 | 5.0577 | 45 |
| 5700 | 0.2037 | 23 | 1094 | 9 | 3.811 | 92 | 5.0622 | 45 |
| 5800 | 0.2060 | 23 | 1085 | 9 | 3.903 | 93 | 5.0667 | 46 |
| 5900 | 0.2083 | 21 | 1076 | 8 | 3.996 | 93 | 5.0713 | 45 |
| 6000 | 0.2104 | 21 | 1068 | 8 | 4.089 | 94 | 5.0758 | 45 |
| 6100 | 0.2125 | 20 | 1060 | 8 | 4.183 | 95 | 5.0803 | 45 |
| 6200 | 0.2145 | 19 | 1052 | 7 | 4.278 | 96 | 5.0848 | 45 |
| 6300 | 0.2164 | 18 | 1045 | 8 | 4.374 | 96 | 5.0893 | 44 |
| 6400 | 0.2182 | 17 | 1037 | 7 | 4.470 | 97 | 5.0937 | 44 |
| 6500 | 0.2199 | 17 | 1030 | 7 | 4.567 | 97 | 5.0981 | 44 |
| 6600 | 0.2216 | 16 | 1023 | 7 | 4.664 | 98 | 5.1025 | 44 |
| 6700 | 0.2232 | 16 | 1016 | 6 | 4.762 | 99 | 5.1069 | 43 |
| 6800 | 0.2248 | 14 | 1010 | 7 | 4.861 | 99 | 5.1112 | 43 |
| 6900 | 0.2262 | 14 | 1003 | 6 | 4.960 | 100 | 5.1155 | 43 |
| 7000 | 0.2276 | 13 | 997 | 6 | 5.060 | 101 | 5.1198 | 43 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2300$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 100 | 0.0036 | 35 | 2272 | 28 | 0.044 | 44 | 4.7878 | 35 |
| 200 | 0.0071 | 36 | 2244 | 28 | 0.088 | 45 | 4.7913 | 35 |
| 300 | 0.0107 | 36 | 2216 | 27 | 0.133 | 45 | 4.7948 | 36 |
| 400 | 0.0143 | 36 | 2189 | 27 | 0.178 | 46 | 4.7984 | 36 |
| 500 | 0.0179 | 36 | 2162 | 27 | 0.224 | 47 | 4.8020 | 36 |
| 600 | 0.0215 | 36 | 2135 | 27 | 0.271 | 47 | 4.8056 | 37 |
| 700 | 0.0251 | 36 | 2108 | 26 | 0.318 | 48 | 4.8093 | 37 |
| 800 | 0.0287 | 37 | 2082 | 26 | 0.366 | 48 | 4.8130 | 37 |
| 900 | 0.0324 | 37 | 2056 | 26 | 0.414 | 49 | 4.8167 | 37 |
| 1000 | 0.0361 | 37 | 2030 | 26 | 0.463 | 50 | 4.8204 | 38 |
| 1100 | 0.0398 | 37 | 2004 | 25 | 0.513 | 50 | 4.8242 | 38 |
| 1200 | 0.0435 | 37 | 1979 | 25 | 0.563 | 51 | 4.8280 | 38 |
| 1300 | 0.0472 | 37 | 1954 | 25 | 0.614 | 51 | 4.8318 | 38 |
| 1400 | 0.0509 | 37 | 1929 | 25 | 0.665 | 52 | 4.8356 | 39 |
| 1500 | 0.0546 | 38 | 1904 | 25 | 0.717 | 53 | 4.8395 | 39 |
| 1600 | 0.0584 | 37 | 1879 | 24 | 0.770 | 54 | 4.8434 | 39 |
| 1700 | 0.0621 | 38 | 1855 | 24 | 0.824 | 54 | 4.8473 | 39 |
| 1800 | 0.0659 | 38 | 1831 | 24 | 0.878 | 55 | 4.8512 | 40 |
| 1900 | 0.0697 | 38 | 1807 | 23 | 0.933 | 56 | 4.8552 | 40 |
| 2000 | 0.0735 | 38 | 1784 | 23 | 0.989 | 56 | 4.8592 | 40 |
| 2100 | 0.0773 | 38 | 1761 | 23 | 1.045 | 57 | 4.8632 | 41 |
| 2200 | 0.0811 | 38 | 1738 | 23 | 1.102 | 58 | 4.8673 | 40 |
| 2300 | 0.0849 | 38 | 1715 | 22 | 1.160 | 59 | 4.8713 | 41 |
| 2400 | 0.8787 | 38 | 1693 | 22 | 1.219 | 60 | 4.8754 | 42 |
| 2500 | 0.0925 | 38 | 1671 | 22 | 1.279 | 60 | 4.8796 | 41 |
| 2600 | 0.0963 | 39 | 1649 | 22 | 1.339 | 61 | 4.8837 | 42 |
| 2700 | 0.1002 | 38 | 1627 | 21 | 1.400 | 62 | 4.8879 | 42 |
| 2800 | 0.1040 | 38 | 1606 | 21 | 1.462 | 63 | 4.8921 | 42 |
| 2900 | 0.1078 | 39 | 1585 | 21 | 1.525 | 63 | 4.8963 | 42 |
| 3000 | 0.1117 | 38 | 1564 | 21 | 1.588 | 64 | 4.9005 | 42 |
| 3100 | 0.1155 | 37 | 1543 | 20 | 1.652 | 65 | 4.9047 | 43 |
| 3200 | 0.1192 | 38 | 1523 | 20 | 1.717 | 66 | 4.9090 | 43 |
| 3300 | 0.1230 | 38 | 1503 | 20 | 1.783 | 67 | 4.9133 | 43 |
| 3400 | 0.1268 | 38 | 1483 | 19 | 1.850 | 68 | 4.9176 | 44 |
| 3500 | 0.1306 | 38 | 1464 | 19 | 1.918 | 69 | 4.9220 | 44 |
| 3600 | 0.1344 | 38 | 1445 | 19 | 1.987 | 70 | 4.9264 | 44 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2300$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1382 | 38 | 1426 | 19 | 2.057 | 70 | 4.9308 | 44 |
| 3800 | 0.1420 | 38 | 1407 | 18 | 2.127 | 71 | 4.9352 | 44 |
| 3900 | 0.1458 | 38 | 1389 | 18 | 2.198 | 73 | 4.9396 | 45 |
| 4000 | 0.1496 | 38 | 1371 | 18 | 2.271 | 73 | 4.9441 | 45 |
| 4100 | 0.1534 | 38 | 1353 | 18 | 2.344 | 74 | 4.9486 | 45 |
| 4200 | 0.1572 | 38 | 1335 | 17 | 2.418 | 76 | 4.9531 | 45 |
| 4300 | 0.1610 | 37 | 1318 | 17 | 2.494 | 76 | 4.9576 | 45 |
| 4400 | 0.1647 | 36 | 1301 | 16 | 2.570 | 77 | 4.9621 | 46 |
| 4500 | 0.1683 | 36 | 1285 | 16 | 2.647 | 78 | 4.9667 | 46 |
| 4600 | 0.1719 | 35 | 1269 | 15 | 2.725 | 79 | 4.9713 | 46 |
| 4700 | 0.1754 | 35 | 1254 | 15 | 2.804 | 81 | 4.9759 | 46 |
| 4800 | 0.1789 | 34 | 1239 | 14 | 2.885 | 81 | 4.9805 | 46 |
| 4900 | 0.1823 | 34 | 1225 | 13 | 2.966 | 82 | 4.9851 | 46 |
| 5000 | 0.1857 | 34 | 1212 | 13 | 3.048 | 83 | 4.9897 | 46 |
| 5100 | 0.1891 | 33 | 1199 | 12 | 3.131 | 84 | 4.9943 | 47 |
| 5200 | 0.1924 | 32 | 1187 | 12 | 3.215 | 85 | 4.9990 | 46 |
| 5300 | 0.1956 | 31 | 1175 | 12 | 3.300 | 86 | 5.0036 | 47 |
| 5400 | 0.1987 | 30 | 1163 | 12 | 3.386 | 87 | 5.0083 | 46 |
| 5500 | 0.2017 | 29 | 1151 | 11 | 3.473 | 87 | 5.0129 | 47 |
| 5600 | 0.2046 | 28 | 1140 | 10 | 3.560 | 88 | 5.0176 | 46 |
| 5700 | 0.2074 | 26 | 1130 | 11 | 3.648 | 89 | 5.0222 | 47 |
| 5800 | 0.2100 | 26 | 1119 | 10 | 3.737 | 90 | 5.0269 | 46 |
| 5900 | 0.2126 | 25 | 1109 | 9 | 3.827 | 90 | 5.0315 | 47 |
| 6000 | 0.2151 | 24 | 1100 | 9 | 3.917 | 91 | 5.0362 | 47 |
| 6100 | 0.2175 | 23 | 1091 | 9 | 4.008 | 92 | 5.0409 | 47 |
| 6200 | 0.2198 | 22 | 1082 | 9 | 4.100 | 93 | 5.0456 | 46 |
| 6300 | 0.2220 | 22 | 1073 | 8 | 4.193 | 94 | 5.0502 | 46 |
| 6400 | 0.2242 | 20 | 1065 | 8 | 4.287 | 94 | 5.0548 | 46 |
| 6500 | 0.2262 | 20 | 1057 | 8 | 4.381 | 95 | 5.0594 | 45 |
| 6600 | 0.2282 | 19 | 1049 | 8 | 4.476 | 95 | 5.0639 | 46 |
| 6700 | 0.2301 | 18 | 1041 | 7 | 4.571 | 96 | 5.0685 | 45 |
| 6800 | 0.2319 | 17 | 1034 | 7 | 4.667 | 97 | 5.0730 | 44 |
| 6900 | 0.2336 | 16 | 1027 | 7 | 4.764 | 98 | 5.0774 | 45 |
| 7000 | 0.2352 | 15 | 1020 | 6 | 4.862 | 99 | 5.0819 | 45 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2400$ f.s.

| $Z = \frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1372 | 38 | 1494 | 19 | 1.966 | 67 | 4.8920 | 44 |
| 3800 | 0.1410 | 39 | 1475 | 20 | 2.033 | 69 | 4.8964 | 44 |
| 3900 | 0.1449 | 38 | 1455 | 19 | 2.102 | 69 | 4.9008 | 44 |
| 4000 | 0.1487 | 38 | 1436 | 19 | 2.171 | 70 | 4.9052 | 44 |
| 4100 | 0.1525 | 38 | 1417 | 19 | 2.241 | 70 | 4.9096 | 45 |
| 4200 | 0.1563 | 38 | 1398 | 19 | 2.311 | 72 | 4.9141 | 45 |
| 4300 | 0.1601 | 37 | 1379 | 18 | 2.383 | 73 | 4.9186 | 45 |
| 4400 | 0.1638 | 37 | 1361 | 17 | 2.456 | 74 | 4.9231 | 45 |
| 4500 | 0.1675 | 37 | 1344 | 17 | 2.530 | 75 | 4.9276 | 45 |
| 4600 | 0.1712 | 37 | 1327 | 17 | 2.605 | 75 | 4.9321 | 46 |
| 4700 | 0.1749 | 37 | 1310 | 16 | 2.680 | 77 | 4.9367 | 46 |
| 4800 | 0.1786 | 36 | 1294 | 16 | 2.757 | 78 | 4.9413 | 46 |
| 4900 | 0.1822 | 36 | 1278 | 15 | 2.835 | 79 | 4.9459 | 47 |
| 5000 | 0.1858 | 36 | 1263 | 15 | 2.914 | 80 | 4.9506 | 47 |
| 5100 | 0.1894 | 36 | 1248 | 15 | 2.994 | 81 | 4.9553 | 46 |
| 5200 | 0.1930 | 35 | 1233 | 14 | 3.075 | 81 | 4.9599 | 47 |
| 5300 | 0.1965 | 34 | 1219 | 13 | 3.156 | 83 | 4.9646 | 47 |
| 5400 | 0.1999 | 33 | 1206 | 13 | 3.239 | 83 | 4.9693 | 47 |
| 5500 | 0.2032 | 32 | 1193 | 13 | 3.322 | 84 | 4.9740 | 47 |
| 5600 | 0.2064 | 31 | 1180 | 12 | 3.406 | 85 | 4.9787 | 47 |
| 5700 | 0.2095 | 30 | 1168 | 12 | 3.491 | 86 | 4.9834 | 47 |
| 5800 | 0.2125 | 29 | 1156 | 11 | 3.577 | 87 | 4.9881 | 48 |
| 5900 | 0.2154 | 28 | 1145 | 11 | 3.664 | 88 | 4.9929 | 47 |
| 6000 | 0.2182 | 27 | 1134 | 10 | 3.752 | 89 | 4.9976 | 47 |
| 6100 | 0.2209 | 26 | 1124 | 10 | 3.841 | 89 | 5.0023 | 48 |
| 6200 | 0.2235 | 26 | 1114 | 10 | 3.930 | 90 | 5.0071 | 47 |
| 6300 | 0.2261 | 25 | 1104 | 9 | 4.020 | 91 | 5.0118 | 47 |
| 6400 | 0.2286 | 24 | 1095 | 9 | 4.111 | 92 | 5.0165 | 47 |
| 6500 | 0.2310 | 23 | 1086 | 9 | 4.203 | 92 | 5.0212 | 46 |
| 6600 | 0.2333 | 22 | 1077 | 8 | 4.295 | 93 | 5.0258 | 47 |
| 6700 | 0.2355 | 21 | 1069 | 8 | 4.388 | 94 | 5.0305 | 47 |
| 6800 | 0.2376 | 20 | 1061 | 8 | 4.482 | 95 | 5.0352 | 46 |
| 6900 | 0.2396 | 19 | 1053 | 8 | 4.577 | 95 | 5.0398 | 46 |
| 7000 | 0.2415 | 18 | 1045 | 7 | 4.672 | 96 | 5.0444 | 46 |

Z

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2500$ f.s.

| $Z = \frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1361 | 38 | 1562 | 21 | 1.882 | 64 | 4.8546 | 43 |
| 3800 | 0.1399 | 38 | 1541 | 20 | 1.946 | 66 | 4.8589 | 44 |
| 3900 | 0.1437 | 38 | 1521 | 20 | 2.012 | 66 | 4.8633 | 44 |
| 4000 | 0.1475 | 38 | 1501 | 20 | 2.078 | 67 | 4.8677 | 44 |
| 4100 | 0.1513 | 38 | 1481 | 20 | 2.145 | 68 | 4.8721 | 44 |
| 4200 | 0.1551 | 38 | 1461 | 19 | 2.213 | 68 | 4.8765 | 44 |
| 4300 | 0.1589 | 37 | 1442 | 19 | 2.281 | 70 | 4.8809 | 45 |
| 4400 | 0.1626 | 37 | 1423 | 19 | 2.351 | 71 | 4.8854 | 45 |
| 4500 | 0.1663 | 38 | 1404 | 18 | 2.422 | 72 | 4.8899 | 45 |
| 4600 | 0.1701 | 38 | 1386 | 18 | 2.494 | 73 | 4.8944 | 46 |
| 4700 | 0.1739 | 37 | 1368 | 17 | 2.567 | 73 | 4.8990 | 46 |
| 4800 | 0.1776 | 38 | 1351 | 17 | 2.640 | 74 | 4.9036 | 46 |
| 4900 | 0.1814 | 38 | 1334 | 17 | 2.714 | 76 | 4.9082 | 46 |
| 5000 | 0.1852 | 38 | 1317 | 17 | 2.790 | 76 | 4.9128 | 46 |
| 5100 | 0.1890 | 37 | 1300 | 16 | 2.866 | 78 | 4.9174 | 47 |
| 5200 | 0.1927 | 37 | 1284 | 16 | 2.944 | 78 | 4.9221 | 47 |
| 5300 | 0.1964 | 36 | 1268 | 15 | 3.022 | 79 | 4.9268 | 47 |
| 5400 | 0.2000 | 35 | 1253 | 15 | 3.101 | 80 | 4.9315 | 47 |
| 5500 | 0.2035 | 34 | 1238 | 14 | 3.181 | 81 | 4.9362 | 47 |
| 5600 | 0.2069 | 34 | 1224 | 13 | 3.262 | 82 | 4.9409 | 47 |
| 5700 | 0.2103 | 33 | 1211 | 13 | 3.344 | 83 | 4.9456 | 47 |
| 5800 | 0.2136 | 32 | 1198 | 13 | 3.427 | 84 | 4 9503 | 48 |
| 5900 | 0.2168 | 31 | 1185 | 12 | 3.511 | 85 | 4.9551 | 48 |
| 6000 | 0.2199 | 31 | 1173 | 11 | 3.596 | 86 | 4.9599 | 48 |
| 6100 | 0.2230 | 30 | 1162 | 11 | 3.682 | 87 | 4.9647 | 48 |
| 6200 | 0.2260 | 29 | 1151 | 11 | 3.769 | 87 | 4.9695 | 48 |
| 6300 | 0.2289 | 27 | 1140 | 11 | 3.856 | 88 | 4.9743 | 47 |
| 6400 | 0.2318 | 27 | 1129 | 10 | 3.944 | 89 | 4.9790 | 48 |
| 6500 | 0.2345 | 26 | 1119 | 10 | 4.033 | 90 | 4.9838 | 48 |
| 6600 | 0.2371 | 25 | 1109 | 9 | 4.123 | 91 | 4.9886 | 47 |
| 6700 | 0.2396 | 24 | 1100 | 9 | 4.214 | 91 | 4.9933 | 48 |
| 6800 | 0.2420 | 23 | 1091 | 9 | 4.305 | 92 | 4.9981 | 47 |
| 6900 | 0.2443 | 22 | 1082 | 9 | 4.397 | 93 | 5.0028 | 48 |
| 7000 | 0.2465 | 21 | 1073 | 8 | 4.490 | 94 | 5.0076 | 48 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

V = 2600 f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 100 | 0.0034 | 35 | 2569 | 30 | 0.039 | 39 | 4.6809 | 34 |
| 200 | 0.0069 | 34 | 2539 | 30 | 0.078 | 40 | 4.6843 | 35 |
| 300 | 0.0103 | 35 | 2509 | 30 | 0.118 | 40 | 4.6878 | 34 |
| 400 | 0.0138 | 35 | 2479 | 29 | 0.158 | 41 | 4.6912 | 35 |
| 500 | 0.0173 | 35 | 2450 | 29 | 0.199 | 41 | 4.6947 | 35 |
| 600 | 0.0208 | 35 | 2421 | 29 | 0.240 | 41 | 4.6982 | 35 |
| 700 | 0.0243 | 35 | 2392 | 29 | 0.281 | 42 | 4.7017 | 36 |
| 800 | 0.0278 | 35 | 2363 | 29 | 0.323 | 43 | 4.7053 | 36 |
| 900 | 0.0313 | 35 | 2334 | 28 | 0.366 | 43 | 4.7089 | 36 |
| 1000 | 0.0348 | 35 | 2306 | 28 | 0.409 | 44 | 4.7125 | 36 |
| 1100 | 0.0383 | 36 | 2278 | 28 | 0.453 | 44 | 4.7161 | 37 |
| 1200 | 0.0419 | 36 | 2250 | 27 | 0.497 | 44 | 4.7198 | 36 |
| 1300 | 0.0455 | 35 | 2223 | 28 | 0.541 | 45 | 4.7234 | 37 |
| 1400 | 0.0490 | 36 | 2195 | 27 | 0.586 | 46 | 4.7271 | 37 |
| 1500 | 0.0526 | 36 | 2168 | 27 | 0.632 | 47 | 4.7308 | 38 |
| 1600 | 0.0562 | 37 | 2141 | 26 | 0.679 | 47 | 4.7346 | 38 |
| 1700 | 0.0599 | 36 | 2115 | 27 | 0.726 | 47 | 4.7384 | 38 |
| 1800 | 0.0635 | 36 | 2088 | 26 | 0.773 | 48 | 4.7422 | 38 |
| 1900 | 0.0671 | 37 | 2062 | 26 | 0.821 | 49 | 4.7460 | 38 |
| 2000 | 0.0708 | 37 | 2036 | 26 | 0.870 | 49 | 4.7498 | 39 |
| 2100 | 0.0745 | 37 | 2010 | 26 | 0.919 | 50 | 4.7537 | 39 |
| 2200 | 0.0782 | 37 | 1984 | 25 | 0.969 | 51 | 4.7576 | 39 |
| 2300 | 0.0819 | 37 | 1959 | 25 | 1.020 | 51 | 4.7615 | 39 |
| 2400 | 0.0856 | 38 | 1934 | 25 | 1.071 | 52 | 4.7654 | 39 |
| 2500 | 0.0894 | 37 | 1909 | 24 | 1.123 | 53 | 4.7693 | 40 |
| 2600 | 0.0931 | 37 | 1885 | 25 | 1.176 | 54 | 4.7733 | 40 |
| 2700 | 0.0968 | 38 | 1860 | 24 | 1.230 | 54 | 4.7773 | 40 |
| 2800 | 0.1006 | 37 | 1836 | 24 | 1.284 | 55 | 4.7813 | 41 |
| 2900 | 0.1043 | 38 | 1812 | 23 | 1.339 | 55 | 4.7854 | 41 |
| 3000 | 0.1081 | 38 | 1789 | 23 | 1.394 | 56 | 4.7895 | 41 |
| 3100 | 0.1119 | 38 | 1766 | 23 | 1.450 | 57 | 4.7936 | 41 |
| 3200 | 0.1157 | 38 | 1743 | 23 | 1.507 | 58 | 4.7977 | 42 |
| 3300 | 0.1195 | 38 | 1720 | 23 | 1.565 | 59 | 4.8019 | 42 |
| 3400 | 0.1233 | 38 | 1697 | 22 | 1.624 | 59 | 4.8061 | 42 |
| 3500 | 0.1271 | 38 | 1675 | 22 | 1.683 | 60 | 4.8103 | 42 |
| 3600 | 0.1309 | 39 | 1653 | 21 | 1.743 | 61 | 4.8145 | 43 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2600$ f.s.

| $Z = \frac{X}{C}$ | $\log B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | $\log C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1348 | 38 | 1632 | 22 | 1.804 | 62 | 4.8188 | 43 |
| 3800 | 0.1386 | 39 | 1610 | 21 | 1.866 | 63 | 4.8231 | 43 |
| 3900 | 0.1425 | 38 | 1589 | 21 | 1.929 | 63 | 4.8274 | 43 |
| 4000 | 0.1463 | 38 | 1568 | 21 | 1.992 | 64 | 4.8317 | 43 |
| 4100 | 0.1501 | 39 | 1547 | 20 | 2.056 | 65 | 4.8360 | 44 |
| 4200 | 0.1540 | 38 | 1527 | 20 | 2.121 | 66 | 4.8404 | 44 |
| 4300 | 0.1578 | 38 | 1507 | 19 | 2.187 | 67 | 4.8448 | 44 |
| 4400 | 0.1616 | 38 | 1488 | 20 | 2.254 | 67 | 4.8492 | 45 |
| 4500 | 0.1654 | 38 | 1468 | 19 | 2.321 | 69 | 4.8537 | 45 |
| 4600 | 0.1692 | 38 | 1449 | 19 | 2.390 | 70 | 4.8582 | 45 |
| 4700 | 0.1730 | 37 | 1430 | 19 | 2.460 | 70 | 4.8627 | 45 |
| 4800 | 0.1767 | 38 | 1411 | 18 | 2.530 | 72 | 4.8672 | 46 |
| 4900 | 0.1805 | 37 | 1393 | 18 | 2.602 | 72 | 4.8718 | 46 |
| 5000 | 0.1842 | 37 | 1375 | 18 | 2.674 | 73 | 4.8764 | 46 |
| 5100 | 0.1879 | 36 | 1357 | 18 | 2.747 | 74 | 4.8810 | 46 |
| 5200 | 0.1915 | 37 | 1339 | 17 | 2.821 | 75 | 4.8856 | 46 |
| 5300 | 0.1952 | 37 | 1322 | 17 | 2.896 | 76 | 4.8902 | 47 |
| 5400 | 0.1989 | 36 | 1305 | 17 | 2.972 | 77 | 4.8949 | 47 |
| 5500 | 0.2025 | 36 | 1288 | 16 | 3.049 | 78 | 4.8996 | 47 |
| 5600 | 0.2061 | 36 | 1272 | 15 | 3.127 | 79 | 4.9043 | 47 |
| 5700 | 0.2097 | 36 | 1257 | 14 | 3.206 | 80 | 4.9090 | 47 |
| 5800 | 0.2133 | 35 | 1243 | 14 | 3.286 | 81 | 4.9137 | 48 |
| 5900 | 0.2168 | 35 | 1229 | 14 | 3.367 | 82 | 4.9185 | 48 |
| 6000 | 0.2203 | 34 | 1215 | 13 | 3.449 | 83 | 4.9233 | 48 |
| 6100 | 0.2237 | 33 | 1202 | 13 | 3.532 | 84 | 4.9281 | 49 |
| 6200 | 0.2270 | 32 | 1189 | 12 | 3.616 | 84 | 4.9330 | 48 |
| 6300 | 0.2302 | 31 | 1177 | 12 | 3.700 | 86 | 4.9378 | 48 |
| 6400 | 0.2333 | 30 | 1165 | 12 | 3.786 | 86 | 4.9426 | 48 |
| 6500 | 0.2363 | 30 | 1153 | 11 | 3.872 | 87 | 4.9474 | 49 |
| 6600 | 0.2393 | 28 | 1142 | 10 | 3.959 | 88 | 4.9523 | 48 |
| 6700 | 0.2421 | 27 | 1132 | 11 | 4.047 | 89 | 4.9571 | 48 |
| 6800 | 0.2448 | 26 | 1121 | 10 | 4.136 | 90 | 4.9619 | 49 |
| 6900 | 0.2474 | 26 | 1111 | 9 | 4.226 | 90 | 4.9668 | 48 |
| 7000 | 0.2500 | 25 | 1102 | 9 | 4.316 | 91 | 4.9716 | 48 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2700$ f.s.

| $Z = \frac{X}{C}$ | $\log B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | $\log C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1335 | 38 | 1702 | 22 | 1.732 | 59 | 4.7841 | 42 |
| 3800 | 0.1373 | 38 | 1680 | 22 | 1.791 | 60 | 4.7883 | 43 |
| 3900 | 0.1411 | 38 | 1658 | 22 | 1.851 | 61 | 4.7926 | 43 |
| 4000 | 0.1449 | 38 | 1636 | 21 | 1.912 | 62 | 4.7969 | 43 |
| 4100 | 0.1487 | 37 | 1615 | 20 | 1.974 | 62 | 4.8012 | 44 |
| 4200 | 0.1524 | 38 | 1595 | 21 | 2.036 | 63 | 4.8056 | 43 |
| 4300 | 0.1562 | 38 | 1574 | 20 | 2.099 | 64 | 4.8099 | 44 |
| 4400 | 0.1600 | 38 | 1554 | 20 | 2.163 | 65 | 4.8143 | 44 |
| 4500 | 0.1638 | 38 | 1534 | 20 | 2.228 | 66 | 4.8187 | 45 |
| 4600 | 0.1676 | 38 | 1514 | 20 | 2.294 | 67 | 4.8232 | 45 |
| 4700 | 0.1714 | 39 | 1494 | 20 | 2.361 | 67 | 4.8277 | 45 |
| 4800 | 0.1753 | 38 | 1474 | 20 | 2.428 | 69 | 4.8322 | 45 |
| 4900 | 0.1791 | 38 | 1454 | 20 | 2.497 | 69 | 4.8367 | 45 |
| 5000 | 0.1829 | 38 | 1434 | 19 | 2.566 | 70 | 4.8412 | 45 |
| 5100 | 0.1867 | 37 | 1415 | 19 | 2.636 | 71 | 4.8457 | 46 |
| 5200 | 0.1904 | 37 | 1396 | 18 | 2.707 | 72 | 4.8503 | 46 |
| 5300 | 0.1941 | 37 | 1378 | 18 | 2.779 | 73 | 4.8549 | 46 |
| 5400 | 0.1978 | 37 | 1360 | 17 | 2.852 | 74 | 4.8595 | 47 |
| 5500 | 0.2015 | 37 | 1343 | 17 | 2.926 | 75 | 4.8642 | 47 |
| 5600 | 0.2052 | 37 | 1326 | 17 | 3.001 | 76 | 4.8689 | 47 |
| 5700 | 0.2089 | 37 | 1309 | 16 | 3.077 | 77 | 4.8736 | 47 |
| 5800 | 0.2126 | 36 | 1293 | 16 | 3.154 | 77 | 4.8783 | 47 |
| 5900 | 0.2162 | 36 | 1277 | 15 | 3.231 | 79 | 4.8830 | 48 |
| 6000 | 0.2198 | 36 | 1262 | 15 | 3.310 | 80 | 4.8878 | 48 |
| 6100 | 0.2234 | 36 | 1247 | 14 | 3.390 | 81 | 4.8926 | 48 |
| 6200 | 0.2270 | 35 | 1233 | 14 | 3.471 | 82 | 4.8974 | 48 |
| 6300 | 0.2305 | 35 | 1219 | 14 | 3.543 | 83 | 4.9022 | 49 |
| 6400 | 0.2340 | 33 | 1205 | 13 | 3.636 | 83 | 4.9071 | 48 |
| 6500 | 0.2373 | 32 | 1192 | 12 | 3.719 | 84 | 4.9119 | 49 |
| 6600 | 0.2405 | 31 | 1180 | 12 | 3.803 | 85 | 4.9168 | 48 |
| 6700 | 0.2436 | 30 | 1168 | 12 | 3.888 | 86 | 4.9216 | 49 |
| 6800 | 0.2466 | 29 | 1156 | 11 | 3.974 | 87 | 4.9265 | 49 |
| 6900 | 0.2495 | 28 | 1145 | 11 | 4.061 | 88 | 4.9314 | 49 |
| 7000 | 0.2523 | 28 | 1134 | 10 | 4.149 | 89 | 4.9363 | 49 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2800$ f.s.

| $Z = \frac{X}{C}$ | log $B'$ | $\Delta_1$ | $u$ | $\Delta_2$ | $T'$ | $\Delta_3$ | log $C'$ | $\Delta_4$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 100 | 0.0033 | 34 | 2768 | 32 | 0.036 | 36 | 4.6163 | 34 |
| 200 | 0.0067 | 34 | 2736 | 31 | 0.072 | 37 | 4.6197 | 34 |
| 300 | 0.0101 | 33 | 2705 | 31 | 0.109 | 37 | 4.6231 | 34 |
| 400 | 0.0134 | 34 | 2674 | 31 | 0.146 | 38 | 4.6265 | 34 |
| 500 | 0.0168 | 34 | 2643 | 31 | 0.184 | 38 | 4.6299 | 34 |
| 600 | 0.0202 | 34 | 2612 | 31 | 0.222 | 39 | 4.6333 | 34 |
| 700 | 0.0236 | 34 | 2581 | 30 | 0.261 | 39 | 4.6367 | 35 |
| 800 | 0.0270 | 35 | 2551 | 30 | 0.300 | 39 | 4.6402 | 35 |
| 900 | 0.0305 | 34 | 2521 | 30 | 0.339 | 40 | 4.6437 | 35 |
| 1000 | 0.0339 | 35 | 2491 | 30 | 0.379 | 40 | 4.6472 | 35 |
| 1100 | 0.0374 | 35 | 2461 | 29 | 0.419 | 41 | 4.6507 | 36 |
| 1200 | 0.0409 | 34 | 2432 | 29 | 0.460 | 42 | 4.6543 | 35 |
| 1300 | 0.0433 | 35 | 2403 | 29 | 0.502 | 42 | 4.6578 | 36 |
| 1400 | 0.0478 | 36 | 2374 | 29 | 0.544 | 42 | 4.6614 | 36 |
| 1500 | 0.0514 | 35 | 2345 | 29 | 0.586 | 43 | 4.6650 | 37 |
| 1600 | 0.0549 | 35 | 2316 | 28 | 0.629 | 43 | 4.6687 | 37 |
| 1700 | 0.0584 | 36 | 2288 | 28 | 0.672 | 44 | 4.6724 | 37 |
| 1800 | 0.0620 | 35 | 2260 | 28 | 0.716 | 45 | 4.6761 | 37 |
| 1900 | 0.0655 | 36 | 2232 | 27 | 0.761 | 45 | 4.6798 | 37 |
| 2000 | 0.0691 | 36 | 2205 | 27 | 0.806 | 46 | 4.6835 | 38 |
| 2100 | 0.0727 | 36 | 2178 | 27 | 0.852 | 46 | 4.6873 | 38 |
| 2200 | 0.0763 | 36 | 2151 | 26 | 0.898 | 47 | 4.6911 | 38 |
| 2300 | 0.0799 | 36 | 2125 | 27 | 0.945 | 47 | 4.6949 | 38 |
| 2400 | 0.0835 | 36 | 2098 | 26 | 0.992 | 48 | 4.6987 | 38 |
| 2500 | 0.0871 | 37 | 2072 | 26 | 1.040 | 49 | 4.7025 | 39 |
| 2600 | 0.0908 | 37 | 2046 | 26 | 1.089 | 49 | 4.7064 | 39 |
| 2700 | 0.0945 | 37 | 2020 | 25 | 1.138 | 50 | 4.7103 | 40 |
| 2800 | 0.0982 | 37 | 1995 | 26 | 1.188 | 50 | 4.7143 | 39 |
| 2900 | 0.1019 | 37 | 1969 | 25 | 1.238 | 51 | 4.7182 | 40 |
| 3000 | 0.1056 | 37 | 1944 | 25 | 1.289 | 52 | 4.7222 | 40 |
| | 0.1093 | 38 | 1919 | 25 | 1.341 | 52 | 4.7262 | 40 |
| | 0.1131 | 37 | 1894 | 25 | 1.393 | 53 | 4.7302 | 41 |
| | 0.1168 | 38 | 1869 | 24 | 1.446 | 54 | 4.7343 | 40 |
| | 0.1206 | 37 | 1845 | 24 | 1.500 | 55 | 4.7383 | 41 |
| | 0.1243 | 38 | 1821 | 24 | 1.555 | 55 | 4.7424 | 41 |
| | 0.1281 | 38 | 1797 | 23 | 1.610 | 56 | 4.7465 | 42 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2800$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1319 | 38 | 1774 | 23 | 1.666 | 57 | 4.7507 | 42 |
| 3800 | 0.1357 | 38 | 1751 | 23 | 1.723 | 57 | 4.7549 | 42 |
| 3900 | 0.1395 | 38 | 1728 | 23 | 1.780 | 58 | 4.7591 | 42 |
| 4000 | 0.1433 | 38 | 1705 | 22 | 1.838 | 59 | 4.7633 | 42 |
| 4100 | 0.1471 | 38 | 1683 | 22 | 1.897 | 60 | 4.7675 | 43 |
| 4200 | 0.1509 | 38 | 1661 | 21 | 1.957 | 60 | 4.7718 | 43 |
| 4300 | 0.1547 | 38 | 1640 | 21 | 2.017 | 61 | 4.7761 | 43 |
| 4400 | 0.1585 | 38 | 1619 | 21 | 2.078 | 63 | 4.7804 | 44 |
| 4500 | 0.1623 | 38 | 1598 | 21 | 2.141 | 63 | 4.7848 | 44 |
| 4600 | 0.1661 | 38 | 1577 | 21 | 2.204 | 64 | 4.7892 | 44 |
| 4700 | 0.1699 | 38 | 1556 | 21 | 2.268 | 65 | 4.7936 | 44 |
| 4800 | 0.1737 | 39 | 1535 | 20 | 2.333 | 66 | 4.7980 | 45 |
| 4900 | 0.1776 | 38 | 1515 | 20 | 2.399 | 66 | 4.8025 | 45 |
| 5000 | 0.1814 | 38 | 1495 | 20 | 2.465 | 67 | 4.8070 | 45 |
| 5100 | 0.1852 | 37 | 1475 | 20 | 2.532 | 68 | 4.8115 | 45 |
| 5200 | 0.1889 | 38 | 1455 | 19 | 2.600 | 69 | 4.8160 | 46 |
| 5300 | 0.1927 | 37 | 1436 | 19 | 2.669 | 70 | 4.8206 | 46 |
| 5400 | 0.1964 | 38 | 1417 | 18 | 2.739 | 71 | 4.8252 | 46 |
| 5500 | 0.2002 | 37 | 1399 | 18 | 2.810 | 72 | 4.8298 | 46 |
| 5600 | 0.2039 | 38 | 1381 | 18 | 2.882 | 73 | 4.8344 | 47 |
| 5700 | 0.2077 | 37 | 1363 | 18 | 2.955 | 74 | 4.8391 | 47 |
| 5800 | 0.2114 | 38 | 1345 | 17 | 3.029 | 75 | 4.8438 | 47 |
| 5900 | 0.2152 | 37 | 1328 | 16 | 3.104 | 76 | 4.8485 | 48 |
| 6000 | 0.2189 | 38 | 1312 | 17 | 3.180 | 77 | 4.8533 | 47 |
| 6100 | 0.2227 | 37 | 1295 | 16 | 3.257 | 78 | 4.8580 | 48 |
| 6200 | 0.2264 | 36 | 1279 | 15 | 3.335 | 79 | 4.8628 | 48 |
| 6300 | 0.2300 | 36 | 1264 | 15 | 3.414 | 79 | 4.8676 | 48 |
| 6400 | 0.2336 | 35 | 1249 | 15 | 3.493 | 80 | 4.8724 | 48 |
| 6500 | 0.2371 | 34 | 1234 | 14 | 3.573 | 81 | 4.8772 | 49 |
| 6600 | 0.2405 | 33 | 1220 | 14 | 3.654 | 83 | 4.8821 | 49 |
| 6700 | 0.2438 | 33 | 1206 | 13 | 3.737 | 83 | 4.8870 | 49 |
| 6800 | 0.2471 | 32 | 1193 | 12 | 3.820 | 84 | 4.8919 | 49 |
| 6900 | 0.2503 | 31 | 1181 | 12 | 3.904 | 85 | 4.8968 | 49 |
| 7000 | 0.2534 | 31 | 1169 | 11 | 3.989 | 86 | 4.9017 | 50 |

(Taken f

| $Z=\frac{X}{C}$ | log $B'$ |
|---|---|
| 100 | 0. |
| 200 | 0. |
| 300 | 0. |
| 400 | [illegible] |
| 500 | [illegible] |
| 600 | [illegible] |
| 700 | |
| 800 | |
| 900 | |
| 1000 | |
| 1100 | |
| 1200 | |
| 13 | |
| 1 | |
| 1 | |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 2900$ f.s.

| $= \frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1304 | 37 | 1847 | 24 | 1.603 | 55 | 4.7183 | 41 |
| 3800 | 0.1341 | 38 | 1823 | 24 | 1.658 | 55 | 4.7224 | 41 |
| 3900 | 0.1379 | 38 | 1799 | 23 | 1.713 | 56 | 4.7265 | 42 |
| 4000 | 0.1417 | 38 | 1776 | 23 | 1.769 | 57 | 4.7307 | 42 |
| 4100 | 0.1455 | 39 | 1753 | 23 | 1.826 | 57 | 4.7349 | 42 |
| 4200 | 0.1494 | 38 | 1730 | 22 | 1.883 | 58 | 4.7391 | 43 |
| 4300 | 0.1532 | 38 | 1708 | 22 | 1.941 | 59 | 4.7434 | 43 |
| 4400 | 0.1570 | 38 | 1686 | 22 | 2.000 | 60 | 4.7477 | 43 |
| 4500 | 0.1608 | 38 | 1664 | 22 | 2.060 | 61 | 4.7520 | 43 |
| 4600 | 0.1646 | 38 | 1642 | 22 | 2.121 | 61 | 4.7563 | 44 |
| 4700 | 0.1684 | 38 | 1620 | 21 | 2.182 | 62 | 4.7607 | 44 |
| 4800 | 0.1722 | 38 | 1599 | 21 | 2.244 | 63 | 4.7651 | 44 |
| 4900 | 0.1760 | 38 | 1578 | 21 | 2.307 | 64 | 4.7695 | 44 |
| 5000 | 0.1798 | 37 | 1557 | 21 | 2.371 | 64 | 4.7739 | 45 |
| 5100 | 0.1835 | 37 | 1536 | 20 | 2.435 | 65 | 4.7784 | 45 |
| 5200 | 0.1872 | 38 | 1516 | 20 | 2.500 | 67 | 4.7829 | 45 |
| 5300 | 0.1910 | 37 | 1496 | 19 | 2.567 | 67 | 4.7874 | 45 |
| 5400 | 0.1947 | 38 | 1477 | 19 | 2.634 | 68 | 4.7919 | 46 |
| 5500 | 0.1985 | 38 | 1458 | 19 | 2.702 | 69 | 4.7965 | 46 |
| 5600 | 0.2023 | 38 | 1439 | 19 | 2.771 | 70 | 4.8011 | 46 |
| 5700 | 0.2061 | 38 | 1420 | 19 | 2.841 | 71 | 4.8057 | 46 |
| 5800 | 0.2099 | 38 | 1401 | 18 | 2.912 | 72 | 4.8103 | 47 |
| 5900 | 0.2137 | 38 | 1383 | 18 | 2.984 | 73 | 4.8150 | 47 |
| 6000 | 0.2175 | 38 | 1365 | 18 | 3.057 | 74 | 4.8197 | 47 |
| 6100 | 0.2213 | 37 | 1347 | 18 | 3.131 | 74 | 4.8244 | 48 |
| 6200 | 0.2250 | 37 | 1329 | 17 | 3.205 | 76 | 4.8292 | 47 |
| 6300 | 0.2287 | 36 | 1312 | 16 | 3.281 | 77 | 4.8339 | 48 |
| 6400 | 0.2323 | 36 | 1296 | 16 | 3.358 | 77 | 4.8387 | 48 |
| 6500 | 0.2359 | 36 | 1280 | 15 | 3.435 | 79 | 4.8435 | 49 |
| 6600 | 0.2395 | 35 | 1265 | 15 | 3.514 | 79 | 4.8484 | 48 |
| 6700 | 0.2430 | 35 | 1250 | 15 | 3.593 | 80 | 4.8532 | 49 |
| 6800 | 0.2465 | 35 | 1235 | 14 | 3.673 | 82 | 4.8581 | 49 |
| 6900 | 0.2500 | 34 | 1221 | 13 | 3.755 | 82 | 4.8630 | 49 |
| 7000 | 0.2534 | 33 | 1208 | 13 | 3.837 | 83 | 4.8679 | 49 |

## TABLE B

(Taken from Ingalls' Table II, *Artillery Circular M*)

$V = 3000$ f.s.

| $Z=\frac{X}{C}$ | log $B'$ | $\Delta_z$ | $u$ | $\Delta_z$ | $T'$ | $\Delta_z$ | log $C'$ | $\Delta_z$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | −10 | |
| 3700 | 0.1298 | 38 | 1922 | 24 | 1.545 | 52 | 4.6865 | 40 |
| 3800 | 0.1336 | 37 | 1898 | 25 | 1.597 | 53 | 4.6905 | 41 |
| 3900 | 0.1373 | 38 | 1873 | 24 | 1.650 | 54 | 4.6946 | 41 |
| 4000 | 0.1411 | 37 | 1849 | 24 | 1.704 | 55 | 4.6987 | 42 |
| 4100 | 0.1448 | 37 | 1825 | 24 | 1.759 | 55 | 4.7029 | 42 |
| 4200 | 0.1485 | 38 | 1801 | 24 | 1.814 | 56 | 4.7071 | 42 |
| 4300 | 0.1523 | 37 | 1777 | 23 | 1.870 | 57 | 4.7113 | 42 |
| 4400 | 0.1560 | 37 | 1754 | 23 | 1.927 | 57 | 4.7155 | 43 |
| 4500 | 0.1597 | 38 | 1731 | 23 | 1.984 | 58 | 4.7198 | 43 |
| 4600 | 0.1635 | 38 | 1708 | 22 | 2.042 | 59 | 4.7241 | 43 |
| 4700 | 0.1673 | 38 | 1686 | 22 | 2.101 | 60 | 4.7284 | 43 |
| 4800 | 0.1711 | 37 | 1664 | 22 | 2.161 | 60 | 4.7327 | 44 |
| 4900 | 0.1748 | 38 | 1642 | 21 | 2.221 | 61 | 4.7371 | 44 |
| 5000 | 0.1786 | 38 | 1621 | 21 | 2.282 | 62 | 4.7415 | 45 |
| 5100 | 0.1824 | 37 | 1600 | 21 | 2.344 | 63 | 4.7460 | 45 |
| 5200 | 0.1861 | 38 | 1579 | 21 | 2.407 | 64 | 4.7505 | 45 |
| 5300 | 0.1899 | 38 | 1558 | 20 | 2.471 | 64 | 4.7550 | 45 |
| 5400 | 0.1937 | 37 | 1538 | 20 | 2.535 | 66 | 4.7595 | 45 |
| 5500 | 0.1974 | 37 | 1518 | 20 | 2.601 | 67 | 4.7640 | 46 |
| 5600 | 0.2011 | 38 | 1498 | 20 | 2.668 | 67 | 4.7686 | 46 |
| 5700 | 0.2049 | 37 | 1478 | 19 | 2.735 | 68 | 4.7732 | 46 |
| 5800 | 0.2086 | 38 | 1459 | 19 | 2.803 | 69 | 4.7778 | 45 |
| 5900 | 0.2124 | 38 | 1440 | 19 | 2.872 | 70 | 4.7823 | 45 |
| 6000 | 0.2162 | 38 | 1421 | 19 | 2.942 | 70 | 4.7868 | 45 |
| 6100 | 0.2200 | 39 | 1402 | 18 | 3.012 | 71 | 4.7913 | 45 |
| 6200 | 0.2239 | 39 | 1384 | 18 | 3.083 | 72 | 4.7958 | 45 |
| 6300 | 0.2278 | 39 | 1366 | 17 | 3.155 | 73 | 4.8003 | 46 |
| 6400 | 0.2317 | 38 | 1349 | 17 | 3.228 | 74 | 4.8049 | 47 |
| 6500 | 0.2355 | 37 | 1332 | 17 | 3.302 | 75 | 4.8096 | 47 |
| 6600 | 0.2392 | 37 | 1315 | 16 | 3.377 | 77 | 4.8143 | 48 |
| 6700 | 0.2429 | 36 | 1299 | 16 | 3.454 | 78 | 4.8191 | 49 |
| 6800 | 0.2465 | 35 | 1283 | 16 | 3.532 | 78 | 4.8240 | 50 |
| 6900 | 0.2500 | 34 | 1267 | 15 | 3.610 | 80 | 4.8290 | 50 |
| 7000 | 0.2534 | 34 | 1252 | 15 | 3.690 | 81 | 4.8340 | 51 |

## TABLE C

Values of the coefficient of form, for projectiles the heads of which are of ogival radius *n* calibers.

| *n* | *c* |
|---|---|
| 2 | 1.00 |
| 3 | 0.82 |
| 4 | 0.71 |
| 5 | 0.64 |
| 6 | 0.58 |
| 7 | 0.54 |

## TABLE D

Values of $D_w$ in degrees, for use with the formula,

$$\text{Deflection for } W \text{ mile wind} = \frac{WZ}{V} \cdot D_w^\circ.$$

| *V* | 1600 | 1700 | 1800 | 1900 | 2000 | 2100 |
|---|---|---|---|---|---|---|
| *Z* | ° | ° | ° | ° | ° | ° |
| 0000 | .0055 | .0055 | .0055 | .0054 | .0054 | .0053 |
| 1000 | .0059 | .0058 | .0058 | .0057 | .0057 | .0056 |
| 2000 | .0061 | .0060 | .0061 | .0060 | .0060 | .0059 |
| 3000 | .0061 | .0062 | .0063 | .0063 | .0063 | .0062 |
| 4000 | .0060 | .0062 | .0063 | .0065 | .0065 | .0065 |
| 5000 | .0059 | .0061 | .0064 | .0066 | .0067 | .0067 |
| 6000 | .0057 | .0061 | .0065 | .0066 | .0068 | .0069 |
| 7000 | .0055 | .0060 | .0064 | .0065 | .0068 | .0070 |
| 8000 | .0054 | .0059 | .0062 | .0064 | .0067 | .0070 |
| 9000 | .0053 | .0057 | .0060 | .0063 | .0066 | .0069 |
| 10000 | .0052 | .0056 | .0059 | .0062 | .0066 | .0069 |
| 11000 | .0051 | .0055 | .0058 | .0061 | .0065 | .0068 |
| 12000 | .0051 | .0054 | .0058 | .0061 | .0064 | .0067 |
| 13000 | .0050 | .0054 | .0057 | .0061 | .0063 | .0067 |
| 14000 | .0050 | .0053 | .0057 | .0060 | .0062 | .0066 |
| 15000 | .0049 | .0053 | .0056 | .0059 | .0062 | .0065 |
| 16000 | .0049 | .0053 | .0056 | .0059 | .0062 | .0065 |
| 17000 | .0049 | .0052 | .0055 | .0058 | .0061 | .0064 |
| 18000 | .0049 | .0052 | .0055 | .0058 | .0061 | .0064 |
| 19000 | .0048 | .0052 | .0055 | .0057 | .0060 | .0063 |
| 20000 | .0048 | .0051 | .0054 | .0057 | .0060 | .0063 |
| 21000 | .0048 | .0051 | .0054 | .0057 | .0060 | .0062 |

## TABLE D—Continued.

| V | 2100 | 2200 | 2300 | 2400 | 2500 | 2600 |
|---|---|---|---|---|---|---|
| Z | ° | ° | ° | ° | ° | ° |
| 0000 | .0053 | .0052 | .0051 | .0050 | .0049 | .0048 |
| 1000 | .0056 | .0056 | .0055 | .0054 | .0053 | .0052 |
| 2000 | .0059 | .0059 | .0058 | .0057 | .0056 | .0055 |
| 3000 | .0062 | .0062 | .0061 | .0060 | .0059 | .0059 |
| 4000 | .0065 | .0065 | .0064 | .0063 | .0063 | .0063 |
| 5000 | .0067 | .0068 | .0067 | .0067 | .0067 | .0067 |
| 6000 | .0069 | .0070 | .0070 | .0070 | .0070 | .0070 |
| 7000 | .0070 | .0071 | .0072 | .0072 | .0072 | .0072 |
| 8000 | .0070 | .0071 | .0072 | .0073 | .0074 | .0074 |
| 9000 | .0069 | .0071 | .0072 | .0074 | .0075 | .0076 |
| 10000 | .0069 | .0072 | .0072 | .0074 | .0075 | .0076 |
| 11000 | .0068 | .0070 | .0071 | .0073 | .0075 | .0076 |
| 12000 | .0067 | .0069 | .0071 | .0073 | .0075 | .0076 |
| 13000 | .0067 | .0069 | .0071 | .0073 | .0074 | .0076 |
| 14000 | .0066 | .0068 | .0070 | .0072 | .0074 | .0076 |
| 15000 | .0065 | .0068 | .0070 | .0072 | .0074 | .0076 |
| 16000 | .0065 | .0067 | .0069 | .0072 | .0073 | .0075 |
| 17000 | .0064 | .0067 | .0069 | .0071 | .0073 | .0075 |
| 18000 | .0064 | .0067 | .0069 | .0071 | .0073 | .0075 |
| 19000 | .0063 | .0066 | .0069 | .0071 | .0073 | .0075 |
| 20000 | .0063 | .0066 | .0068 | .0071 | .0073 | .0075 |
| 21000 | .0062 | .0065 | .0068 | .0071 | .0073 | .0075 |

| V | 2600 | 2700 | 2800 | 2900 | 3000 | 3100 |
|---|---|---|---|---|---|---|
| Z | ° | ° | ° | ° | ° | ° |
| 0000 | .0048 | .0048 | .0047 | .0047 | .0046 | .0046 |
| 1000 | .0052 | .0051 | .0050 | .0050 | .0049 | .0048 |
| 2000 | .0055 | .0054 | .0054 | .0053 | .0052 | .0051 |
| 3000 | .0059 | .0058 | .0057 | .0056 | .0055 | .0054 |
| 4000 | .0063 | .0062 | .0060 | .0060 | .0059 | .0058 |
| 5000 | .0067 | .0066 | .0064 | .0063 | .0063 | .0062 |
| 6000 | .0070 | .0069 | .0068 | .0067 | .0066 | .0065 |
| 7000 | 0072 | .0072 | .0072 | .0071 | .0070 | .0069 |
| 800 | 74 | .0075 | .0075 | .0074 | .0074 | .0073 |
|  | 76 | .0077 | .0077 | .0077 | .0077 | .0077 |
|  | 76 | .0077 | .0078 | .0078 | .0079 | .0079 |
|  | 76 | .0078 | .0079 | .0079 | .0080 | .0081 |
|  | 76 | .0078 | .0079 | .0080 | .0081 | .0082 |
|  | 076 | .0078 | .0079 | .0080 | .0081 | .0082 |
|  |  | 78 | .0079 | .0081 | .0082 | .0083 |
|  |  | 78 | .0079 | .0081 | .0082 | .0083 |
|  |  | 77 | .0079 | .0081 | .0082 | .0083 |
|  |  | 77 | .0079 | .0081 | .0082 | .0084 |
|  |  | 77 | .0079 | .0081 | .0082 | .0084 |
|  |  | 077 | .0079 | .0081 | .0083 | .0084 |
|  |  | 0077 | .0079 | .0081 | .0083 | .0084 |
|  |  | .0077 | .0079 | .0081 | .0083 | .0084 |

of w

(Computed from the formula

$$\frac{\Delta V}{V} = .00867 \left\{ 2^{.032t} - 2^{.032 \times 70} \right\}$$

$$= .00867 \left\{ 2^{.032t} - 4.73 \right\}.)$$

## TABLE K

$$K = [3.3333 - 10]\, R^2 = .2154 \left(\frac{R}{1000}\right)^2$$

in which $K$ is the curvature in feet and $R$ the range in yards.

The curvature in feet for ranges at 1000 yards interval are given in the following table.

Curvature in Feet

| Range | Curvature | Δ | Range | Curvature | Δ |
|---|---|---|---|---|---|
| yds. | feet | feet | yds. | feet | feet |
| 1000 | 0.22 | 0.64 | 12000 | 31.02 | 5.38 |
| 2000 | 0.86 | 1.08 | 13000 | 36.40 | 5.82 |
| 3000 | 1.94 | 1.51 | 14000 | 42.22 | 6.25 |
| 4000 | 3.45 | 1.94 | 15000 | 48.47 | 6.67 |
| 5000 | 5.39 | 2.36 | 16000 | 55.14 | 7.11 |
| 6000 | 7.75 | 2.80 | 17000 | 62.25 | 7.54 |
| 7000 | 10.55 | 3.24 | 18000 | 69.79 | 7.97 |
| 8000 | 13.79 | 3.66 | 19000 | 77.76 | 8.40 |
| 9000 | 17.45 | 4.09 | 20000 | 86.16 | 8.83 |
| 10000 | 21.54 | 4.52 | 21000 | 94.99 | 9.26 |
| 11000 | 26.06 | 4.96 | 22000 | 104.25 | |

## TABLE P

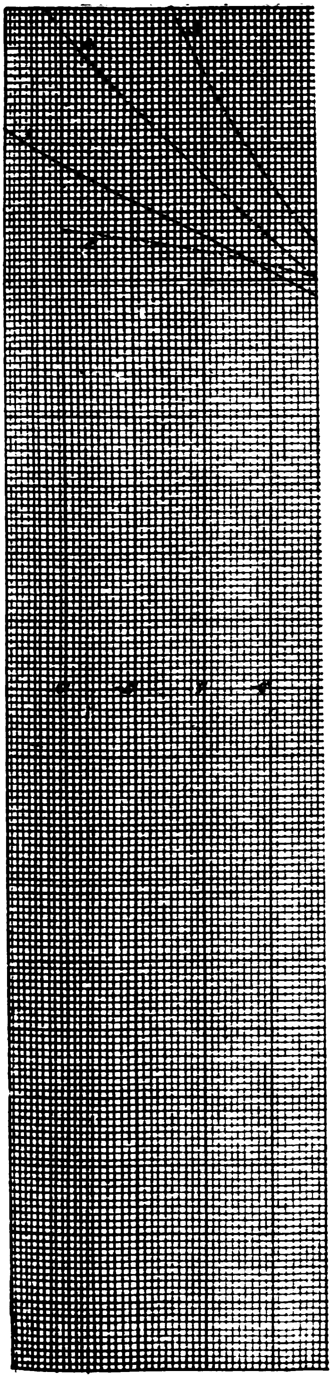
Table of Values of $P_v$.

| $v$ | $P_v$ | Δ | $v$ | $P_v$ | Δ |
|---|---|---|---|---|---|
| 100 | .018 | 26 | 1600 | 1.177 | 136 |
| 200 | .044 | 33 | 1700 | 1.313 | 144 |
| 300 | .077 | 41 | 1800 | 1.457 | 128 |
| 400 | .118 | 48 | 1900 | 1.585 | 129 |
| 500 | .166 | 55 | 2000 | 1.714 | 128 |
| 600 | .221 | 62 | 2100 | 1.842 | 129 |
| 700 | .283 | 70 | 2200 | 1.971 | 129 |
| 800 | .353 | 77 | 2300 | 2.100 | 128 |
| 900 | .430 | 85 | 2400 | 2.228 | 129 |
| 1000 | .515 | 92 | 2500 | 2.357 | 128 |
| 1100 | .607 | 99 | 2600 | 2.485 | 129 |
| 1200 | .706 | 107 | 2700 | 2.614 | 128 |
| 1300 | .813 | 114 | 2800 | 2.742 | 129 |
| 1400 | .927 | 121 | 2900 | 2.871 | 129 |
| 1500 | 1.048 | 129 | 3000 | 3.000 | |

For oblique impact, $\alpha$ being the angle of incidence (measured from the normal to the plate) the following table of percentages to be *subtracted* from perforations at normal impact for each value of $\alpha$, is given:

TABLE Q

| $\alpha$ | % | $\alpha$ | % |
|---|---|---|---|
| ° | | ° | |
| 0 | 0 | 25 | 6 |
| 5 | 0 | 30 | 8 |
| 10 | 1 | 35 | 11 |
| 15 | 2 | 40 | 15 |
| 20 | 4 | 45 | 19 |



# THE SERVICE OF SECURITY AND INFORMATION IN COAST DEFENSE

By 1st Lieutenant WILLIAM N. PORTER, Coast Artillery Corps

It has long been a popular fancy, even among our own officers, that the Coast Artillery is a second line of defense; that it can come into action only after the defeat of our fleet; and that in many ways we shall be assisted by the Navy in whatever manner is necessary to secure the information of the enemy which we must have. But, when this idea is examined closely, its fallacy is very quickly exposed.

With a coast line as long as ours, and a navy as small, we very easily more than divide the first line with our sailor brothers; and the completion of the Panama Canal has added greatly to the probability of coast defense falling entirely to us even in a war with a single power, while an attack from two allied nations would still further increase that probability. Furthermore, the first principle of naval strategy is to seek out and destroy the enemy's ships; a principle which in itself contemplates the exposure of our coast fortifications, at least temporarily.

Certainly, the posts in the Philippines and Hawaii can expect no adequate naval defense or assistance; and, with our battle fleet on one side of the Canal, the home forts on the other cannot hope for much from the reserve of obsolete battleships and cruisers assigned to that coast. It therefore follows, if the country is justly to place its reliance upon us, that we must arrange an adequate defense, complete in all its parts, entirely our own, and independent of the Navy, from which we are so far removed in times of peace and preparation.

## INFORMATION

It is, of course, impossible for us, even in a war of but a few months, to be always at our guns and stations, ready to repel any form of attack that an alert enemy may send against us. We are not unlike a mobile army, well entrenched, which must act on the defensive; and we must, like such an army, be well protected from surprise; the more so, because, unlike a mobile army, we have no possible supports or reserve to bring into action. Every means, therefore, which we can find and build up, must be employed in procuring the necessary security and information.

"Military Information," says the Field Service Regulations, "may be divided into two classes, namely, (1) that collected by the General Staff in time of peace, and (2) that obtained by the troops, after the outbreak of hostilities."

Although this definition was made for mobile forces, it applies with equal weight to the Coast Artillery. With the first class we have nothing to do, so far as its collection is concerned; but the gathering of the information which will make up the second class is work for which we must carefully prepare.

The information of the enemy on which we must rely, must, it would seem, be obtained by ourselves; for while it is true that the Navy has planned, as long ago as 1903, for a system of coast information by a naval patrol (G. O. 128, N.D., 1903), which includes a harbor entrance patrol, yet, in view of the fact that a system of security and information depends for its success upon smooth working, and in view of the fact, already alluded to, that our Navy and Coast Artillery are wholly dissociated in time of peace and preparation, can we rely upon a naval patrol? Moreover, scout ships to be effective, must be commanded by officers who will be able to estimate such situations as may arise, and communicate their information promptly, and with such clearness that the coast defense commander may thoroughly understand it and rely upon it after the interchange of a single message; and when it is remembered that the Naval Academy was stripped in 1898 of every boy, except some few members of the fourth class, in order to provide officers for the little fleet that was ours at that time, it can readily be imagined that there will be few among the commissioned personnel who will be spending their time on harbor scout work. Furthermore, a mere division of responsibility might put the attacked port in the position of the proverbial gentleman who fell between two stools. With our small merchant fleet forced into our harbors and the Navy busy elsewhere, we can hope, with the present arrangements, for very little knowledge of an enemy's whereabouts; and how his whereabouts can be beclouded, even unintentionally, was abundantly shown in the case of the Spanish fleet in our last war, while the European conflict has already given many illustrations of it; and for the security and comfort of our seaports, we must know when an attack is imminent. In general, then, we must obtain directly our own information, though the so-called naval district scouts, consisting of revenue cutters and like craft, and operating at a considerable distance from the coast, should be of great assistance to us, provided they will supply information to us directly.

A Coast Artillery service of information, therefore, becomes necessary. Such a service should include at least the following:

1. A Coast Artillery information division.
2. A chain of wireless stations connecting coast defenses.
3. Coast Artillery scout and patrol vessels for the patrolling of each harbor mouth.
4. At least one scouting aeroplane for each coast defense.
5. Coast guard observing stations.

### INFORMATION DIVISION

When war is imminent, or political relations strained, a Coast Artillery Information Division should be formed in Washington, under the Chief of Coast Artillery, with a branch division at the headquarters of each artillery district. In addition to collecting and supplying information to the coast defenses, this bureau should be in close touch with the Navy Department, as a knowledge of the whereabouts of our own fleet, is, of course, exceedingly important to coast defense commanders.

### RADIO STATIONS

Many of our coast defenses are already equipped with wireless apparatus of a limited sort; but, so far as the writer knows, these stations have never been used for inter-defense communication. Each coast defense should have a wireless equipment of sufficient range to communicate easily with the coast defenses to its north and south, and the frequent interchange of messages should be insisted upon. We now have the facilities for the training of operators, and are turning out plenty of men capable of handling such stations.

The uses of such a system are so obvious that it is unnecessary to dwell upon them. It should be mentioned, however, that these stations should be a part of the Coast Artillery, not of the Signal Corps. They must be manned and controlled by our own personnel, to secure the maximum of efficient service for our purposes.

### HARBOR PATROL

The advantages of scout and patrol vessels, operating at a distance of about fifty miles from the port to be defended, are equally obvious.

Each boat must be of a speedy type, equipped with wireless; and the fleet for each harbor must patrol in one of the naval systems, such as are fully described in Grant's *School of the Ship.* These boats must belong to the Coast Artillery and be manned by it.

We have, at the present time, some fifty officers who are recent graduates of the United States Naval Academy at Annapolis. Most of them have had actual experience afloat since graduation, ranging in time from a few months to, in some cases, two or three years. All have been trained for engine room as well as deck duty. Their classmates, still in the Navy, and many of them with but little more sea duty, are, in a great number of cases, in command of small torpedoboats and submarines. Our navy yards are full of obsolete torpedoboats and submarines, many of which are annually stricken from the Navy register, broken up for junk, or sold. These boats are all good enough for service of a limited kind, and are retired principally because of the lack of officers and crews to man them.

If these boats could be turned over to the War Department, and a method provided for enlisting ex-bluejackets and sailormen to form their crews, the Annapolis graduates in the Corps would prove competent to handle them; and under the present conditions we can expect additional recruits from the Naval Academy each year Let permission be obtained for the officers chosen for the engine rooms and the command of these little vessels to serve with the Fleet for a few months each year, and we shall quickly have a harbor patrol system that will be able to give results with but little cost; and, best of all, it will be a part of the Coast Artillery Corps, and available for even more serious work, which will be touched upon at the close of this paper.

### AEROPLANE

The scouting aeroplane, of the hydro-aeroplane type, could supplement the work of these craft, and, with the great radius of observation possible to it, give additional information. It would also be highly useful in the detection of mines and submarines.

### OBSERVING STATIONS

Coast guard observing stations have long been contemplated. They should be prepared at once, equipped with telephones and signalling apparatus, and the manning personnel trained for its duties. We cannot count on the early mobilization of the coast guard proper, and must be ready at least to start the work ourselves. The system, therefore, should be thoroughly organized in time of peace, its manning force provided and instructed, if we expect it to be efficient in time of actual need.

So much for a brief sketch of what should be embraced in an outer service of information, its parts having only been touched upon in this paper. There must also be an inner service of information which will include a service of security.

### SECURITY

"The Service of Security embraces all those measures taken by a command to protect itself from observation, annoyance, and surprise by the enemy."

As has been stated, we are always in the position of an entrenched force awaiting an attack. If, then, a service of security is of importance to a mobile force, whose position should normally be one for offense, it is doubly so for us.

The forms of an attack which any coast defense may expect can be determined very largely in advance by the geographical position and features of that defense, and the existing stage of the war. In general, these attacks may consist of one of the following:

1. Attack by hostile agents.
2. Torpedoboat raids.
3. Submarine boat raids.
4. Attempts to block channels.
5. Attack from airships.
6. Attack by first or second class ships.
7. Attack by landing forces.

Any of these are probable at any stage of a war, depending, as to probability, on the stage of the war and geographical features.

With the actual conduct of a defense against any of the above, this paper has nothing to do; but the service of security must embrace such resistance as is necessary to enable the forts to prepare for any of these forms, and to guard against surprise and observation.

An attack by hostile agents is most probable immediately before or after the actual outbreak of hostilities, although, as in the cases of spies, such an attack may take place at any time. Other than spying, such an attack might consist of an attempt, perhaps by a single individual in the enemy's pay, to destroy, by means of bombs or hand grenades, such things as mining casements, searchlights, etc., or to cut electric cables.

We have not, in some cases, been particularly far-sighted in preparation for defense against this sort of attack. The writer knows, for example, of one mining casemate situated on a much-travelled road that is not even under the control of the military authorities. A street car line runs along this road from a nearby city. A well placed hand grenade would make the mine defense in that harbor useless for a very considerable period of time. Many of our electric cables are still above ground, and could easily be cut; and it is not a difficult task to blow the muzzle off a gun.

Security against such attacks must be accomplished in times of peace by making the interior of our coast fortifications of a far more secret nature than they are at present; and, when political relations are at all strained, active patrolling must begin at once.

A torpedoboat raid is the most probable form of attack at any period of a war, and certainly the most probable in the early stages. Primary ships are too valuable to risk against coast works, at least until the defending navy is completely demolished. Occasions can be cited, of course, when attacks from battleships might be expected, but the greatly increased range of the modern torpedo (7500 yards), and the fact that torpedoboats, and even submarines, now carry guns of considerable caliber, make these smaller craft the most likely weapons to be used against coast batteries. When we remember that we have never fired a service shot at any thing moving with even half the speed of the modern torpedoboat, and the great injury that such vessels could do to shipping, naval drydocks, and the open rears of batteries, the value of timely warning against such an attack can be seen.

For security against such raids a system should include:

1. Scout boats and patrols.
2. Fixed beams.
3. Eclipsed lights.
4. Booms and breakwaters.

### SCOUT BOATS

Scout boats have already been dicussed. For night work they should be drawn in close to the mouth of the harbor in order that the territory to be covered by each boat may be as small as possible. Each boat should be equipped with light bombs such as have been in use in the Navy for some years. These bombs are fired into the air in the direction of a possible torpedoboat, and throw a brilliant white light over a circle several hundred yards in diameter. The bombs and apparatus for discharging them are inexpensive.

### SEARCHLIGHTS

Sweeping beams should be discarded as a method of picking up entering torpedoboats, and they will be after a few attempts to locate this type of craft. It has been the writer's privilege to be present on several occasions when flotillas of torpedoboats, with lights out, have made sham night attacks on our battle fleet. Each of the sixteen battleships had from six to ten searchlights at her disposal, each light controlled by an officer; and yet time after time some of these boats approached to within 2000 yards without being discovered. Those boats were, necessarily, headed directly for the guns that might destroy them, while in our own case no such happy combinations of circumstance would exist. Torpedoboat officers will tell you that they are many times swept by searchlight beams without being located by the hundreds of eyes which are watching for just such an occurrence. It is true that we know the general directions from which such attacks must come; but, for the actual discovery of entering boats, sentry, or fixed, beams should be used. The fighting lights would, of course, follow the little vessels as well as possible.

The ideal arrangement for sentry beams is to have two large searchlights mounted opposite to each other, and as near to the entrance of the harbor as possible. Each light should have sufficient power to reach well beyond the center of the channel. They should be low, well protected from gun fire by emplacements, and have independent power plants. They should, of course, bear directly on each other, and so throw a broad beam of light directly across the harbor mouth. There should be sufficient observers for each beam to admit of their being divided into watches of not more than two hours each. The obvious disadvantage of this scheme is the great cost.

### ECLIPSED LIGHTS

The system of eclipsed lights is a fairly good one for discovering an entering vessel, although the nature of the craft cannot be determined until it has been picked up by a searchlight beam, following its discovery. For this method, two boxes are placed in the same positions as the searchlights mentioned in fixed beams, except that they are as near to the water line as possible. These boxes are enclosed on three sides, and at the top and bottom, but have an open face toward each other. Each box contains a light, which may be made by anything from a lantern to a good sized electric bulb. An observer is stationed behind each box, and looks across the channel at the light in the box opposite to him. When the observer at one box sees the light he is watching eclipsed, he knows that a floating object of some sort has passed between him and the light opposite, and he immediately fires a Very's pistol into the air. One observer might, conceivably, make a mistake; but if the other observer also sees the light he is watching eclipsed, and fires his pistol, it is good evidence that something has passed, or is passing, between the two. A small scout boat should lie anchored near a line between the two boxes, and send off a light bomb toward the center of the channel as soon as the first Very's signal is seen. The light from this bomb should illuminate the entering craft for a sufficient length of time to enable a searchlight to pick it up without difficulty. If a mine yawl is used for the small scout boat mentioned, this makes a very cheap, and rather effective system.

### BOOMS AND BREAKWATERS

Booms and breakwaters were sometimes used in our Civil

War, but for slightly different purposes than are now contemplated in countries where they are a part of the coast defense system. Practically all of the harbors of England are protected by them, to the extent to which they provide protection.

In this system the harbor entrances are closed, except for a broad channel, by breakwaters, the channel opening being closed completely at night by floating obstructions called booms. These booms consist of heavy timbers about thirty feet long, and at least one foot in diameter, lashed together by steel cables. They necessitate the use by the enemy of boom smashers, which must, of course, be heavier and slower than torpedoboats. Certain batteries should be designated as boom protectors, and a fighting light should be ready to assist in boom defense.

Many of our harbors will permit of the use of booms without the erection of other breakwaters than have already been constructed. This method of protection is a cheap one and provides almost complete safety against a surprise attack by torpedoboats. Booms should be constructed in times of peace, and the harbors occasionally closed for practice purposes.

Submarines can be detected by scouting aeroplanes under usual day conditions. By night, booms provided with hanging nets seem to offer the only possible protection, other than mines, against such craft.

### EXAMINATION SERVICE

Attempts to block fairways and channels by the sinking of apparently peaceful vessels are best provided against by the early establishment of an examination service. This should include:

1. A previously designated examination anchorage and a signal, the display of which will notify shipping that examination is being enforced.
2. An examining harbor boat, equipped with a gun, and under the command of an officer.
3. An examination battery.

The examination anchorage should be so far beyond the channel entrance that, if it became necessary to sink a would-be blocker, the examination battery would not be compelled to play her own game for her. The guns of the examination battery should be of sufficient power to sink a vessel at long range.

Mine planters come under the class of vessels seeking to block channels, and as mines laid even beyond the range of our heaviest guns would prove a dangerous blockade, mine planters should be dealt with by the extended defense afforded by the scout and patrol vessels. The Japanese used mines laid just beyond the range of the coast guns in a very effective manner during the Russo-Japanese War.

### AIR ATTACK, ETC.

Observers, scouting aeroplanes, and upward rays from searchlights seem to offer the only present means of detecting an overhead attack in advance. The night lights at batteries and stations should be as few as possible. The noise of an enemy's aeroplane might be detected by scout vessels, in some instances, and reported by wireless. Each coast defense should have some form of gun for use against such attacks and reconnaissances.

Security from attacks by landing forces must be obtained by the methods contemplated in Field Service Regulations, supplemented by the coast guard observing stations.

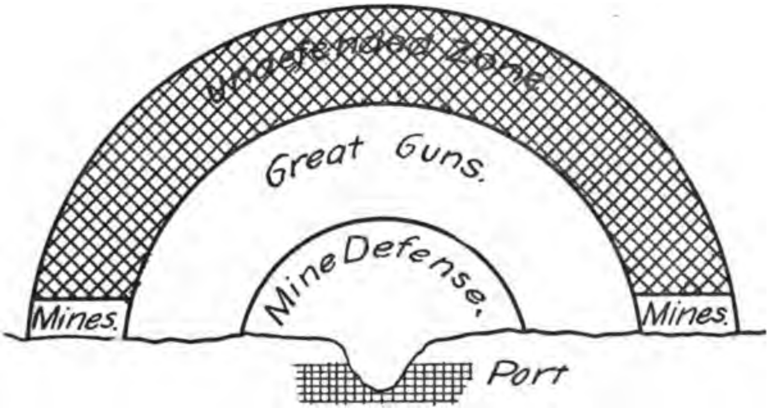
The service of information dealt with at the beginning of this paper should furnish us with complete security from surprise attacks by first and second line ships.

## Extended Defense

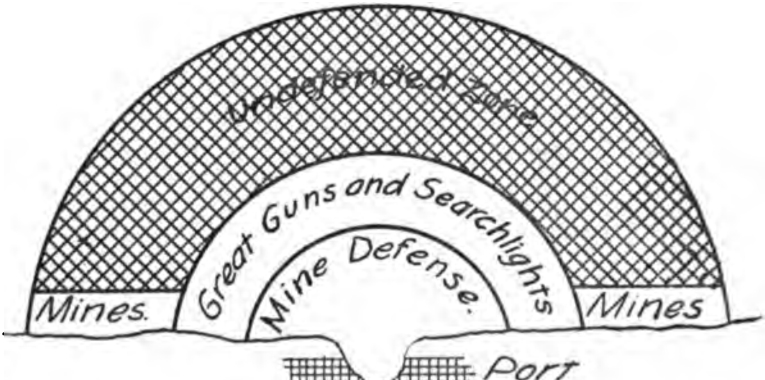
Sufficient duties have been indicated to show the necessity for scout and patrol vessels; but their possible fighting functions must not be neglected. The problem of advanced defense does not properly come under the heading of this article, but since this is, in part, a plea for the use of such vessels by the Coast Artillery, it will not be out of place to touch on that subject.

It has been amply proved that the gun on shore cannot be kept up to the standard of the gun on shipboard as far as range is concerned. Each new battleship appears with larger, newer guns, of high muzzle velocity and great danger space, while we of the coast defense must sit behind more or less antiquated weapons. It cannot be denied that our present coast armament is not sufficiently powerful to cope with the new conditions with which we are faced; and it is apparent that some greater offensive power is necessary to us if we are to remain the coast defense.

Our present armament is wofully insufficient as far as range and penetration is concerned, and we cannot hope for any great increase in range or muzzle velocity in the near future. The result is that, due to the increasing power of naval guns, there is a growing space in front of our harbors



Day
Fig. 1



Night
Fig. 2

1561

which can only be called an undefended zone, and from which a first class battleship with modern guns can, without any danger to herself, smother our batteries with her fire. Anchored mines require shoal water, so that the limit of their protection is quickly reached, once we place them beyond the harbor entrance. At night, the limit of our effective gun fire is shortened to the range of our searchlights, and the undefended zone is much increased in extent. An attempt to show these zones by day and night, although not to scale, has been made in the accompanying sketches.

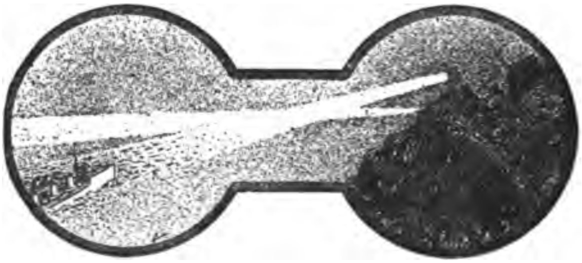
Our most serious future problem will be the protection of this zone; and the only solution is in an active or extended defense; and this is the more serious duty which the scouting torpedoboats and submarines must perform.

Every Coast Artilleryman should be familiar with Sir Percy Scott's letter to the *Times* (London) on the submarine as the successor to the battleship. No dreadnought fleet, he says in effect, will dare to approach a coast defended by submarines and torpedoboat flotillas; and the British losses in the North Sea have already made his words prophetic.

The gun must always remain the last defense, it is true; but the task of manning it is about to sink into a very secondary place, if the signs point truly. A submarine of the newest class costs but half as much as a two-gun twelve-inch battery and its emplacements, and no twelve-inch shell has, at long range, the power that has now been proved for the torpedo. These are facts which should call for deep consideration; and unless we contemplate a life of effort which will be of but little real use to the country which we serve, we had best turn our eyes in this new direction.

Coastal submarines and torpedoboats are not necessarily more naval weapons than are mine planters; and it is apparent that we must soon sink to a secondary position or take the lead in the *new* coast defense which will most certainly soon be appearing.

It will be worth while for us to spend some time now in thinking about it.



# A SPOTTER'S CARD AND A DANGER-SPACE CORRECTION CARD

By Captain HUGH J. B. McELGIN, Coast Artillery Corps

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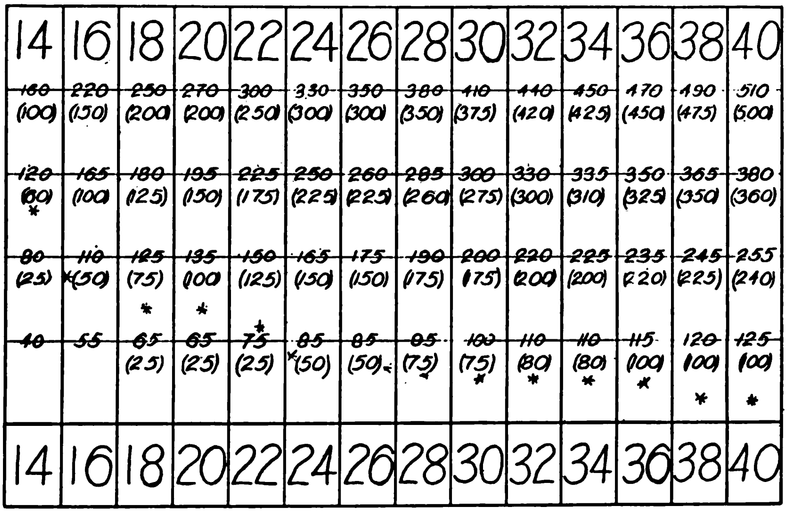
## The Spotter's Card

The principle of the "Spotter's Card" is familiar, but it is believed the form and arrangement of the one here described is somewhat original.



| 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 160<br>(100) | 220<br>(150) | 250<br>(200) | 270<br>(200) | 300<br>(250) | 330<br>(300) | 350<br>(300) | 380<br>(350) | 410<br>(375) | 440<br>(420) | 450<br>(425) | 470<br>(450) | 490<br>(475) | 510<br>(500) |
| 120<br>(60)<br>* | 165<br>(100) | 180<br>(125) | 195<br>(150) | 225<br>(175) | 250<br>(225) | 260<br>(225) | 285<br>(260) | 300<br>(275) | 330<br>(300) | 335<br>(310) | 350<br>(325) | 365<br>(350) | 380<br>(360) |
| 80<br>(25) | 110<br>*(50) | 125<br>(75)<br>* | 135<br>(100)<br>* | 150<br>(125) | 165<br>(150) | 175<br>(150) | 190<br>(175) | 200<br>(175) | 220<br>(200) | 225<br>(200) | 235<br>(220) | 245<br>(225) | 255<br>(240) |
| 40 | 55 | 65<br>(25) | 65<br>(25) | *<br>75<br>(25) | 85<br>*(50) | 85<br>(50) | 95<br>(75) | 100<br>(75)<br>* | 110<br>(80)<br>* | 110<br>(80)<br>* | 115<br>(100)<br>* | 120<br>(100)<br>* | 125<br>(100)<br>* |
| 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |

The Spotter's Card 1562

The large figures, 14—40, at top and bottom, are the first two figures of the ranges, 1400—4000 yards. The card is a combination of several targets, each represented by the space between two vertical lines. The targets are crossed by horizontal lines, ¼, ½, ¾, and 4/4 up the target. On each line are figures in black which indicate how far beyond the target a shot has fallen when the spotter's line of sight to the slick cuts the target at the height of that particular line. Below these figures are others in red,* which indicate by how much the range should be diminished for the next shot in order to put that shot in the center of the target (center of the danger space).

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* The figures that should be entered in red on a spotter's card for use, are entered on the card represented here in parentheses.

On each target is an asterisk so located that, if the spotter's line of sight to the slick cuts the target at or below the height of the asterisk, the spotter may know that a hit has been made.

The uses of the card and its application to the prescribed system for firing rapid fire batteries are obvious.

The spotter should be trained to report, "Up ¼ (½, ¾, or whatever is indicated)." His assistant or the B.C. himself can then determine from the card the distance the shot fell beyond the target, or the correction, if any, to be applied in order to put the next shot in the center of the target.

If the spotter's station is in prolongation of the course of the target, the spotter should, of course, report in terms of yards over or short; the B.C. or the spotter's assistant determining from the target for the range the correction, if any, to be applied in order to place the next shot in the center of the target.

The card shown is for the 6-inch B.L.R., Model 1903, m.v. 2600 f.s., and height of spotter's station 70 feet.

## THE DANGER SPACE CORRECTION CARD

The purpose of this card, or table, is to enable a battery commander to determine, within reasonable limits, the correction to be applied to the first range of a new target, if he has, at a materially different range, already placed the center of impact on the center of another target.

Its use is very simple. Assume that firing ceased when the range to the first target was 1500 yards, and that the range to the new target is 4000 yards. In the column headed 1500 (yards) will be found the figures 40* in red (indicating 4000 yards) and opposite these −75 (meaning −75 yards) in black. This indicates that the new correction should be down, or minus, 75 yards from the correction last used.

The values of the corrections opposite the ranges* (in red) in the columns headed 1000-6000, are obtained by assuming a certain height of target (10 feet was assumed for the table presented herewith) and calculating the danger spaces (corrected for height of site) for each 500 yards of range from 1000 yards to whatever range is desired; then determining the

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* The figures that should be entered in red on a danger space correction card for use, are entered on the card presented herewith in parentheses.

3" 15-pr. R. F. Gun
M. V. 2600 f s.

# DANGER SPACE CORRECTION CARD

Height of battery 0 feet

Center of impact at center of target

| In | R | Out | 1000 | | 1500 | | 2000 | | 2500 | | 3000 | | 3500 | | 4000 | | 4500 | | 5000 | | 5500 | | 6000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +75 | (10) | 0 | (10) | 0 | (10) | + 75 | (10) | +100 | (10) | +125 | (10) | +150 | (10) | +150 | (10) | +150 | (10) | +160 | (10) | +160 | (10) | +170 | (10) | +170 |
| +25 | (15) | −75 | (15) | − 75 | (15) | 0 | (15) | + 25 | (15) | + 50 | (15) | + 75 | (15) | + 75 | (15) | + 75 | (15) | +100 | (15) | +100 | (15) | +100 | (15) | +100 |
| +25 | (20) | −25 | (20) | −100 | (20) | − 25 | (20) | 0 | (20) | + 25 | (20) | + 50 | (20) | + 50 | (20) | + 50 | (20) | + 75 | (20) | + 75 | (20) | + 75 | (20) | + 75 |
| +25 | (25) | −25 | (25) | −125 | (25) | − 50 | (25) | − 25 | (25) | 0 | (25) | + 25 | (25) | + 25 | (25) | + 25 | (25) | + 50 | (25) | + 50 | (25) | + 50 | (25) | + 50 |
| 0 | (30) | −25 | (30) | −150 | (30) | − 75 | (30) | − 50 | (30) | − 25 | (30) | 0 | (30) | 0 | (30) | 0 | (30) | + 25 | (30) | + 25 | (30) | + 25 | (30) | + 25 |
| 0 | (35) | 0 | (35) | −150 | (35) | − 75 | (35) | − 50 | (35) | − 25 | (35) | 0 | (35) | 0 | (35) | 0 | (35) | + 25 | (35) | + 25 | (35) | + 25 | (35) | + 25 |
| +45 | (40) | 0 | (40) | −150 | (40) | − 75 | (40) | − 50 | (40) | − 25 | (40) | 0 | (40) | 0 | (40) | 0 | (40) | + 25 | (40) | + 25 | (40) | + 25 | (40) | + 25 |
| 0 | (45) | 0 | (45) | −160 | (45) | −100 | (45) | − 75 | (45) | − 50 | (45) | − 25 | (45) | − 25 | (45) | − 25 | (45) | 0 | (45) | 0 | (45) | 0 | (45) | 0 |
| 0 | (50) | 0 | (50) | −160 | (50) | −100 | (50) | − 75 | (50) | − 50 | (50) | − 25 | (50) | − 25 | (50) | − 25 | (50) | 0 | (50) | 0 | (50) | 0 | (50) | 0 |
| 0 | (55) | −25 | (55) | −170 | (55) | −100 | (55) | − 75 | (55) | − 50 | (55) | − 25 | (55) | − 25 | (55) | − 25 | (55) | 0 | (55) | 0 | (55) | 0 | (55) | 0 |
| 0 | (60) | 0 | (60) | −170 | (60) | −100 | (60) | − 75 | (60) | − 50 | (60) | − 25 | (60) | − 25 | (60) | − 25 | (60) | 0 | (60) | 0 | (60) | 0 | (60) | 0 |
| | | | 1000 | | 1500 | | 2000 | | 2500 | | 3000 | | 3500 | | 4000 | | 4500 | | 5000 | | 5500 | | 6000 | |

algebraic difference between ½ the danger space for each range in the column and ½ that for the range at the top of the column.

For example, for the column headed 1000, assume,

D.S. for 1000 yds. = 400 yds.; ½ = 200.
“ “ 1500 “ = 250 “ ½ = 125: difference = −75 yds.
“ “ 1000 “ = 400 “ ½ = 200.
“ “ 2000 “ = 200 “ ½ = 100: difference = −100 yds.

For the column headed 3000, assume,

D.S. for 3000 yds. = 100 yds.; ½ = 50.
“ “ 1000 “ = 400 “ ½ = 200: difference = +150 yds.
“ “ 3000 “ = 100 “ ½ = 50.
“ “ 1500 “ = 250 “ ½ = 125: difference = +75 yds.

On the left of the card are columns marked “In”; “R”; and “Out.” R means “Range”; and the figures in the columns headed “In” and “Out” indicate the corrections which should be applied, at the ranges indicated, to keep the center of impact on the center of a target moving toward or away from the battery.

To illustrate. Assume a target “coming in”; center of impact placed on center of target (target hit approximately half-way up). Correction used to get on will be good, until the target is at range of 4000 yards. Here a further correction of +25 yards should be made.

This will suffice until the range has decreased to 2500 yards, when another increase of 25 yards should be ordered.

Assume target “going out” and the center of impact properly placed at a range of 1500 yards; then a correction of −25 yards should be made at 2000, 2500, 3000, and 5500 yards to keep it so.

The column for target “going out” is obviously of the greater importance, since, if the center of impact be placed, at any range, on the center of a target “coming in” and the same range correction be retained during the run-in of the target, the center of impact will remain on the target but will be located lower and lower as the range decreases; while, if it be placed, at a short range, on the center of a target going out, the correction required to put it there will be so great that the target may attain to a range at which this correction will be greater than the danger space.

# A MORTAR BATTERY COMMANDER'S CHECKING BOARD

By Captain CLAUDE E. BRIGHAM, Coast Artillery Corps

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## Object

The object of the board is to place before the battery commander's eye, by means of curves, a graphical indication of the results of the work of the fire control section. The curves enable the battery commander to see at a glance whether any material error has been introduced into the firing data, and thus prevents laying the piece on incorrect data and wasting ammunition, as well as preventing wild and dangerous shooting.

The board was in use at daily drills at Battery King throughout the outdoor period of 1913 and was used during both day and night target practice of that year.

## Description

The board consists of two parts, the board proper and the T-square.

The board proper is an ordinary blackboard about five and a half feet high. Near the top of the board is cut a slot in which moves the head of the T-square. An azimuth scale and an elevation scale (mortar arm zone strip) graduated on cross-section paper, are pasted across the top of the board above and below the slot, respectively, as shown in the figure. Horizontal white lines are ruled at intervals of one inch on the surface of the board.

The scale of the board is 1 inch = 1 degree, and 1 inch = 100 yards.

The head of the T-square slides in the slot between the azimuth and elevation scales.

On the left side of the head of the T-square is pasted the drift scale, with the zero of the scale at the fiducial edge of the arm of the T-square.

On a small rod, or bar, fastened to the head of the T-square just above the drift scale, a sliding pointer is provided. Two cross-wires set in reading windows are provided for accurate reading of azimuth and elevation, as shown in the figure.

### Operation

Set the T-square to the elevation, in the proper zone, shown on the display board at the booth, or as received by the operator over a head-set cut in on the data line to booths, and make a vertical mark where the fiducial edge of the arm of the T-square crosses the first horizontal line on the board.

Set the sliding pointer to the same elevation on the drift scale.

Set the T-square to the azimuth of the corrected set-forward point shown on the display board at the booth, or as received by the operator over a head-set cut in on the data line to booths, and make a vertical mark where the fiducial edge of the arm of the T-square crosses the first horizontal line on the board. Then immediately move the T-square so that the upper end of the sliding pointer points to the same azimuth and make another vertical mark where the fiducial edge of the arm of the T-square crosses the first horizontal line.

These operations give the first points of three different curves—the time-elevation, or time-range, curve, the corrected time-azimuth curve, and the uncorrected time-azimuth curve.

Repeat the above operations for each set of data and join points belonging to similar settings of the arm. The result is the three curves above referred to.

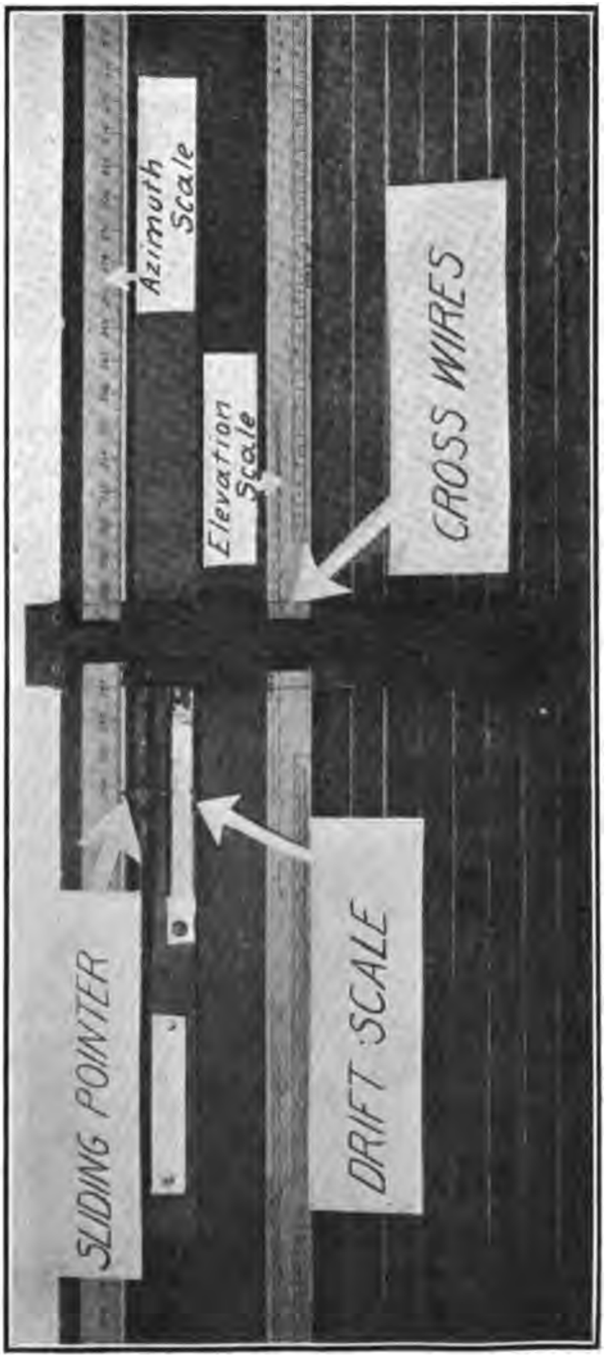
A break will, of course, occur in the corrected time-azimuth curve whenever the zone changes, and the operator writes the figure corresponding to the new zone across the top of the break.

The uncorrected time-azimuth curve and the time-elevation, or time-range, curve should be smooth throughout.

The relation between corrected and uncorrected time-azimuth curves affords a check on the work at the deflection board, since these curves should be slightly diverging or slightly converging in any zone, depending on whether the target is decreasing or increasing in range.

The smooth running of the uncorrected time-azimuth curve past a change in zone indicates the correctness of the first corrected azimuth in a new zone.

A bend at any point in either the corrected time-azimuth curve or the uncorrected time-azimuth curve, without a corresponding bend in the other, indicates error.



1563

A Mortar Battery Commander's Checking Board

A bend in all curves at the same point indicates a change in the course of the target.

A break in the curves, caused by the introduction by the battery commander of a correction due to observation of fire, will, of course, be anticipated by him in amount and direction, and will cause no concern.

## GENERAL

For localities having a wide field of fire, to avoid making the board unduly wide, the azimuth scale can be made in two, or even in three, strips overlapping in azimuth. These strips should be pasted across the top of the board and a slot for the T-square provided beneath each strip. This would require an additional reading window with cross-wire on the T-square for elevation setting; or, perhaps better, a T-square with a movable reading window for the elevation scale.

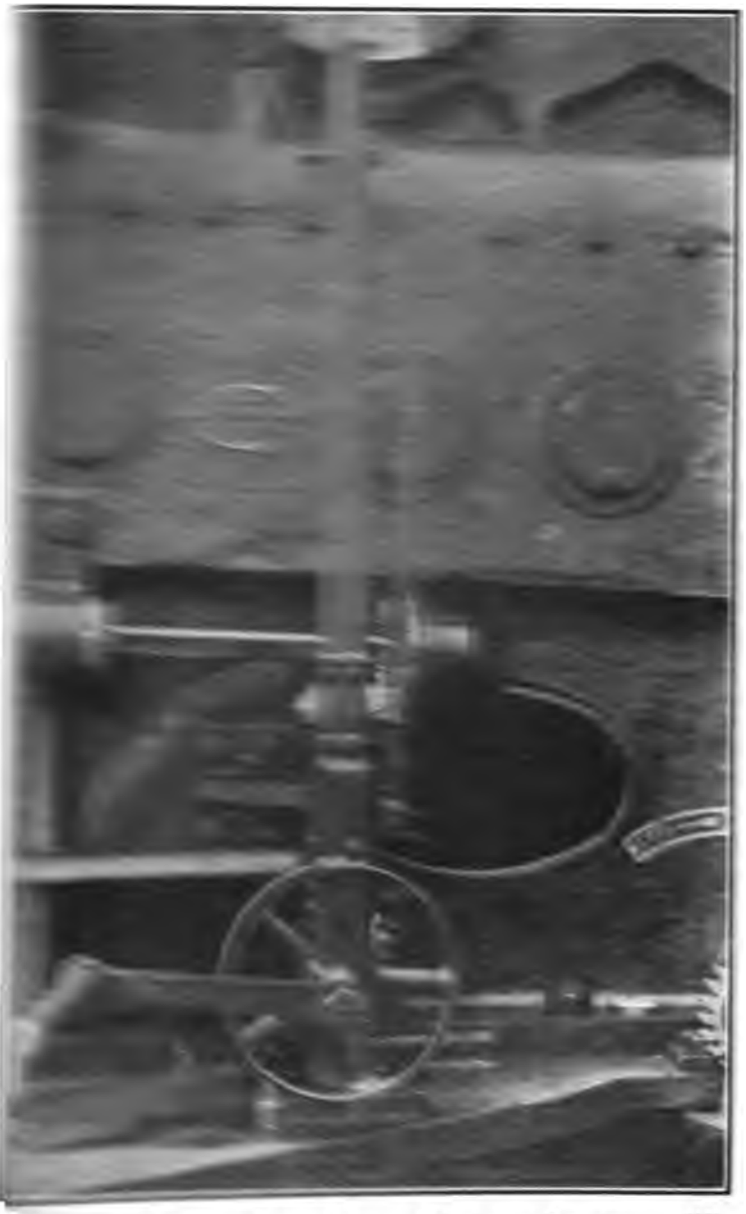
# THE BELCHER SLOW-MOTION ELEVATING DEVICE FOR 12-INCH BARBETTE GUNS

By Lieutenant WILLIAM C. HARRISON, Coast Artillery Corps

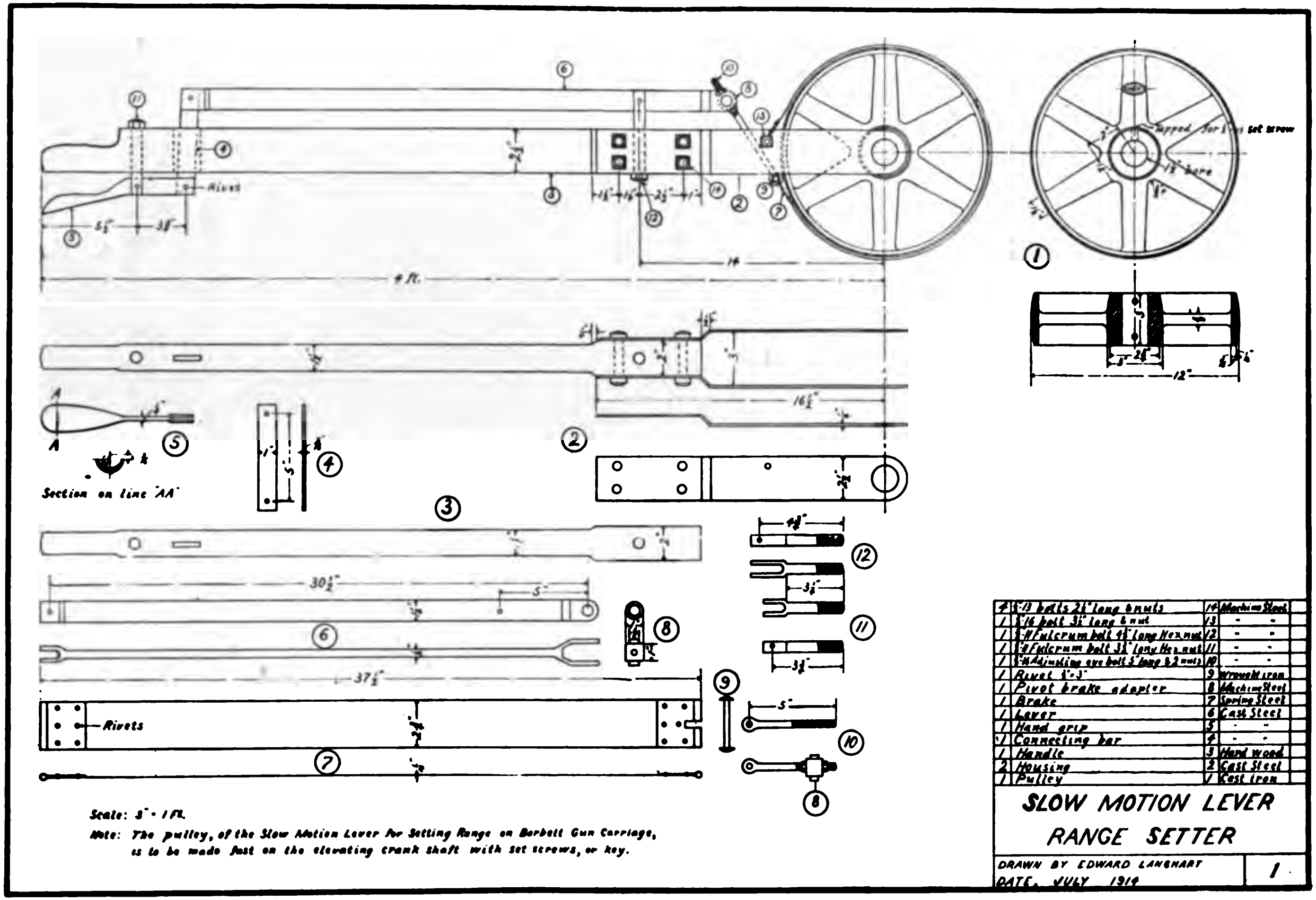
The Belcher Slow Motion Elevating Device for the 12-inch Barbette Gun Carriage, designed and constructed by Sgt. B. C. Belcher, 26th Co., C. A. C., has proved itself, in the recent practices of Battery Wilhelm, of the greatest advantage in the rapid and accurate setting in range of a 12-inch barbette gun.

The greatest difficulty encountered by the writer in the last two years in the handling and operation of barbette guns, a difficulty which was not overcome till the installation of this device, has been the inability quickly and accurately to set the gun in range, due to the great stiffness in the system of elevating gears and to the fact that the man at the elevating handle is unable to see the range disk, his manipulation of the handle, therefore, having to be controlled by signal, either by hand or mouth, from the range setter. This new device eliminates, as far as the construction of gun and carriage will permit, these two great faults.

Using the elevating handle, it is practically impossible to fire a series of shots at one-minute intervals from one gun; at least, that has been the writer's experience at the two different barbette gun batteries with which he has served. For, allowing for time for the gun to return to battery, to open breech, sponge out, and reload, it is well above the average if the gun is ready to be elevated in forty or forty-two seconds; and, allowing four seconds to elevate to the approximate range, there are left of a one-minute interval, with the most rapid work on the part of the gun crew throughout the operation of loading, fourteen to sixteen seconds in which to set the gun exactly in range (the average time left for this step has been found to be about 10 seconds); however, with the ordinary elevating handle, it is a matter of luck if accurate setting is accomplished in that time. It is easy to set to within twenty or thirty yards of the correct range, but difficulty is encountered in



The Beecher Slow-Motion Elevating Device 1584



| | | | | |
|---|---|---|---|---|
| 4 | ½-13 bolts 2½" long & nuts | 14 | Machine Steel | |
| 1 | ⅜-16 bolt 3½" long & nut | 13 | " " | |
| 1 | ⅝-11 Fulcrum bolt 4¾" long Hex nut | 12 | " " | |
| 1 | ⅝-11 Fulcrum bolt 3¾" long Hex nut | 11 | " " | |
| 1 | ⅜-16 Adjusting eye bolt 5" long & 2 nuts | 10 | " " | |
| 1 | Rivet ⅜"×3" | 9 | Wrought iron | |
| 1 | Pivot brake adapter | 8 | Machine Steel | |
| 1 | Brake | 7 | Spring Steel | |
| 1 | Lever | 6 | Cast Steel | |
| 1 | Hand grip | 5 | " " | |
| 1 | Connecting bar | 4 | " " | |
| 1 | Handle | 3 | Hard wood | |
| 2 | Housing | 2 | Cast Steel | |
| 1 | Pulley | 1 | Cast iron | |

SLOW MOTION LEVER
RANGE SETTER

DRAWN BY EDWARD LANGHART
DATE, JULY 1914

1

Scale: 3" = 1 ft.

Note: The pulley, of the Slow Motion Lever for Setting Range on Barbett Gun Carriage, is to be made fast on the elevating crank shaft with set screws, or key.

DETAILS OF THE BELCHER SLOW-MOTION ELEVATING DEVICE

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The indistinct fractions in the legend are: 1st line, 2½; 2nd line, 3/8; 3rd line, 5/8, and 4¾; 4th line, 5/8 and 3¾; 5th line, 3/8; 6th line, 3/8.

setting the exact range. The series of elevating gears is so stiff that it takes the entire strength of one man to depress the gun, and even then he is unable to give it a steady continuous motion of depression: the gears usually stick and the range disk jumps anywhere from 10 to 50 yards. Refinement is an impossibility.

It is at this important stage that the Belcher Elevating Device is of the greatest assistance.

The range setter holds the handle of the new device in his right hand, and at the same time has his eyes in front of and close to the range disk, where he can best observe his work. At the command to elevate, Numbers 5 and 6 elevate by means of the elevating handles to approximately 100 yards above the range to be set; the range setter calls halt; and, without further command, No. 5 immediately takes up the back lash. The range setter then can quickly depress the gun with a steady continuous motion to the exact range, for there is such a great gain in power, the power being more than doubled, that depression can easily be accomplished with one hand.

Since the construction of the device prevents a motion of elevation by means of its handle, the range setter in the excitement of actual firing need not be concerned with the question as to whether the last motion is one of depression or elevation —it must be depression.

Sergt. Belcher installed this device on both guns at Battery Wilhelm immediately prior to this year's firing. The time for the series of seven shots at the second practice was exactly four minutes, which the writer believes to be a time record for 12-inch barbette guns. In the first practice, though the time was greater, no loss of time was caused by any delay in the setting of ranges.

The device is easily constructed, is inexpensive, and is easily assembled without injury or disfiguration of any of the parts of the gun or carriage. With a day's practice, any range setter can become accustomed to its quick and accurate use.

## DESCRIPTION OF THE BELCHER SLOW MOTION ELEVATING DEVICE

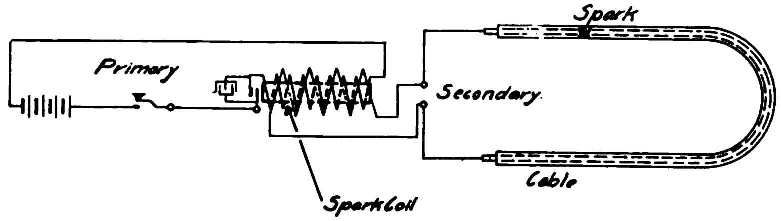
The Belcher Slow Motion Device for the 12-inch Barbette Gun Carriage consists of a cast-iron pulley mounted on and attached to the elevating shaft, about one foot from its end, y means of a set-screw or a key. Mounted on the elevating aft also is the housing, two cast-steel bars, their upper ends being riveted to a hard wood handle. Around the pulley is a spring steel brake, one end of which is firmly bolted to the housing above the pulley, the other end passing between the bars of the housing and being fastened to a lever of cast-steel by an adjusting eye-bolt. This lever is pivoted about seven inches from its lower end, its upper end being riveted to a connecting bar which, after passing through a groove in the wooden handle, is riveted to a hand grip.

Clasping the hard wood handle and the hand grip in the right hand and tightening the grip, tightens the spring steel brake on the pulley, and the gun can then be easily depressed by pulling the handle to the rear.

# TO LOCATE OPEN BREAKS IN SINGLE OR MULTIPLE CONDUCTOR CABLE

By 1st Lieutenant CLAIR W. BAIRD, Coast Artillery Corps

Attach the secondary leads of an ordinary spark coil (1″, 1½″, or 2″) to the ends of the conductor at fault. Attach the primary leads of the coil to three or four cells of the storage-battery, the cells in series. The break is found by listening along the cable for the crack of the spark as it jumps across the gap caused by the break.



1566

This method has been thoroughly tried by the author and found successful, breaks being located within an inch in the middle conductor of seven conductor cable a half mile long. It has also been tried on a mile of nineteen conductor cable with equal success.

# PROFESSIONAL NOTES

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## PHOTOGRAPHING PROJECTILES BY MEANS OF ILLUMINATION FROM ELECTRIC SPARKS

By C. Cranz, P. A. Günther, Captain, 49th Regiment, Field Artillery,
and F. Külp, Captain, 118th Regiment Infantry

Translated from the German for the JOURNAL OF THE UNITED STATES
ARTILLERY by Charles A. Junken

The following article is for the purpose of enlarging upon the methods adopted in 1887 by Prof. E. Mach, in collaboration with P. Salcher and L. Mach, for obtaining photographs by means of the electric spark.

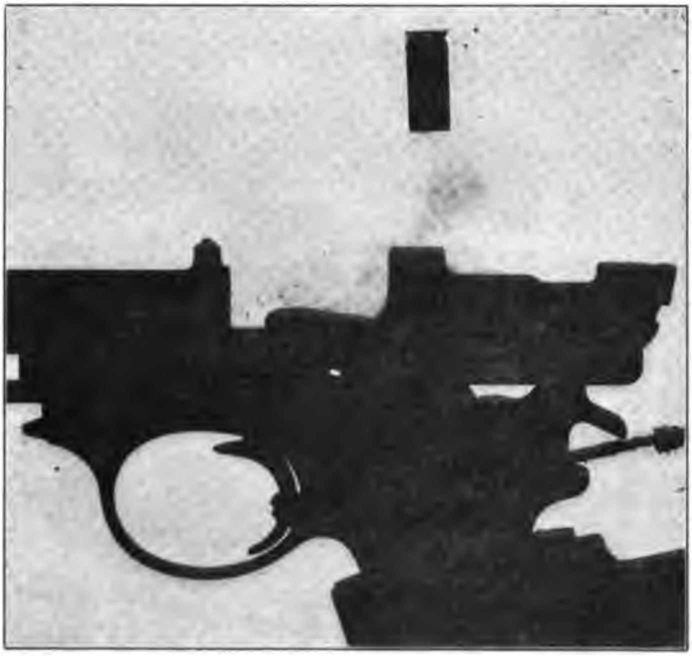

FIG. 1. 1567

Machs' electric spark photography has been so widely quoted in all sorts of technical periodicals, that its fundamental principles may now be considered as generally known. E. Mach himself employed for his photographs a condensing lens, that is to say, a concave mirror in conjunction with a camera. V. Boys at a later date (1896) modified Mach's methods by obtaining, by means of the electric spark, simple shadow pictures (silhouettes) of approximately full size upon sensitized plates, without using concave mirrors or lenses. The methods are similar in that a shadow picture of the object is obtained, that is to say, a silhouette, in which the outline alone of the various objects appears. Examples of such silhouettes are shown in Figs. 1 to 7.

Fig. 1, a print made by the simple shadow method of V. Boys, shows an automatic pistol at the moment of discharge.

Figs. 2 to 6 are photographs taken by the Mach process in conjunction with the Töpler obscuration, or light reducing, process.*

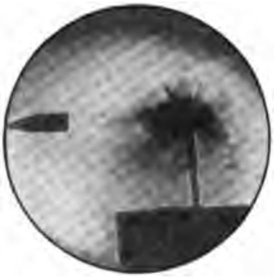

FIG. 2. 1568

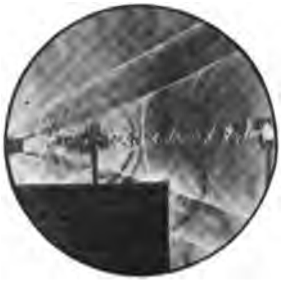

FIG. 3. 1569

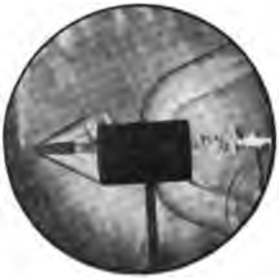

FIG. 4. 1570

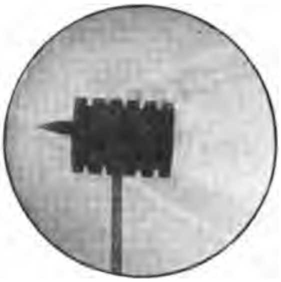

FIG. 5. 1571

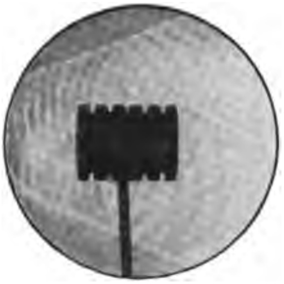

FIG. 6. 1572

Fig. 2 shows a small-arms bullet, with head waves, tail waves, and eddies behind the bullet; the photograph was taken with a slight degree of obscuration (*abblendung*). The bullet has just perforated a screen. Fig 3 represents the same with a stronger obscuration; here the bullet has almost passed beyond the field of view. At the place where a little wooden screen has been perforated by the bullet, an impact wave of air has broadened out to spherical form; and the same thing has occurred at the corner of the table on which the little wooden screen stands; also, the position of discharge of the electric spark is visible at the extreme right edge of the field of view.

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* The editor of the *Zeitschrift fur das Gesamte Schiess-und Sprengstoffwesen* has kindly explained that this process (*Topler Schlierenabblendung*) consists in darkening the field of view by means of a blackened metal block advanced so far toward the axial line of the camera lens as to cause the field of view just to begin to show dark. (*Schilere*, a space in which the refractive power differs from that of the surrounding medium; *Abblendung*, obscuration.)—Tr.

The headwaves are reflected by the table top according to the law of mirrors. In. Fig 4, the bullet has passed through a metal tube. The waves which originally accompanied the projectile have been cut off by the tube, and appear as sections of circular arcs, which was naturally to be expected. After passage through the tube the waves have formed anew.

Similar photographs were earlier obtained by T. Terada and M. Okôchi in Tokio (see the Japanese periodical *Tokyo Sugaku-Buturigakkwai Kizi*, 2d series, Vol. IV, No. 20, 1908, page 402, and Plate II, cuts 13 to 15).

Figs. 5, 6, and 7 were obtained in the Laboratory for Ballistic Instruction. It is to be observed that the head and tail waves are to be considered as envelopes of Huyghen's elementary waves. The bullet passes through a metal tube open at the ends and perforated above and below with many holes. We see in Fig. 5 how the elementary wave formed by the holes are enveloped by the head wave. Fig. 6 is the same taken an instant later; here the tail wave forms an envelope for the elementary waves. Fig. 7 is the same as Fig. 5, except that it is taken by the simple shadow method, without mirrors and lenses.

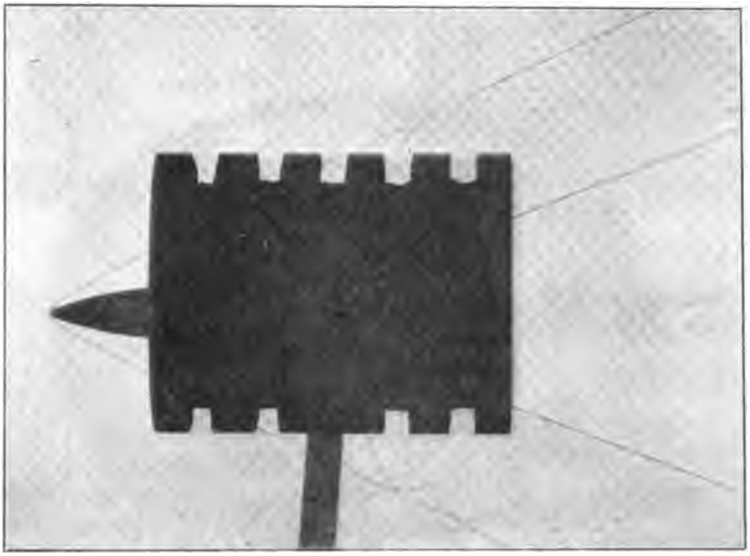


FIG. 7. 1573

The shadow methods employed by Mach and Boys cannot be dispensed with, when it is a question of obtaining photographic records of air waves and eddies; for then difference in refractive power (*schlieren*) must be dealt with. On the other hand, where difference in refractive power (*gaschlieren*) does not enter, but it is a question merely of the details of an opaque body, from a ballistic point of view photographs made by ordinary methods are quite satisfactory. In such photographs, as is well known, the face of the object which is toward the camera is illuminated by direct or indirect rays of the sun or some other source of continuous light; but if the object to be caught is in very rapid motion, when continuous illumination is employed, sufficiently instantaneous closing of the shutter must be assured; and while it is possible to obtain in ordinary instantaneous photography an exposure of 1/20000 of a second, yet even that brief interval is far too great for obtaining sharp definition in the case of many mechanical movements, and especially in the case of those with which we are concerned in ballistics. When, for instance, a wheel of 500 mm. circumference revolves at a rate of 12,000 revolutions per minute, a point on the circumference has passed over a distance of 5 mm. in 1/20000 of a second; so, if the wheel is photographed to half size, the definition of a point on the circumference is reduced by its extension through 2.5 mm. If a projectile is traveling at the rate of 900 m.-sec. and is photographed to 1/10 its natural size, the definition of a point is reduced by its extension through 4.5 mm., since the projectile moves during the exposure 15 mm. On the other hand, sufficiently instantaneous exposure

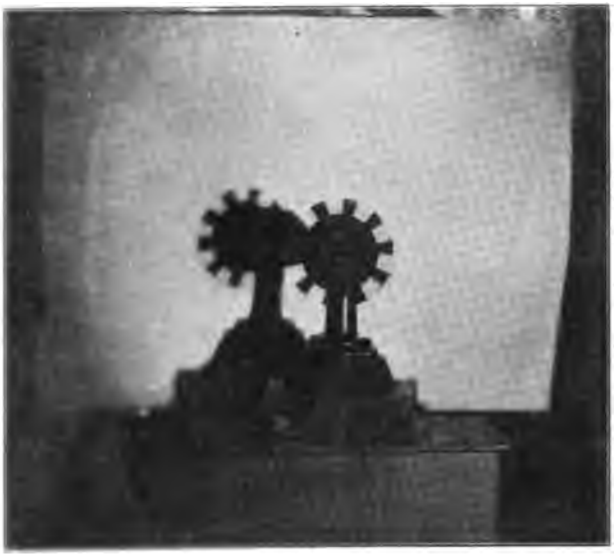


FIG. 8.

1574

is attainable in illumination by means of an electric spark, the duration of the spark light, determined by various methods, being from 1/3 to 1/10 of a millionth of a second.

The method for obtaining a photograph by the light of an electric spark is naturally similar to that employed for securing a photograph of a stroke of lightning on a dark night: the camera is opened till the light shines, and is then closed. C. Cranz in 1909 obtained some negatives by illuminating the face of the object with the electric spark (see *Zeitschrift, etc.*, Vol. 4, of page 323), the spark being discharged through a mercury arc-lamp. ar pictures were subsequently published by Herr H. Boas in Berlin, vately printed pamphlet, in which the face of the object was illumi- y spark light, a reflector being employed. Amongst other things, graphed a revolving wheel (Fig. 8).

employing a great number of condensers we have lately resumed ts with face illumination; and, in Fig. 9 and those following, we shall, by means of many examples, show that, in face illumination with spark light, details within the contour of rapidly moving objects appear with thoroughly satisfactory definition. Some of those photographs we published in July of last year in *Schuss und Waffe*, Vol. 6, No. 20, page 397; and by arrangements with the editors of both periodicals concerned we republish in the present article, the earlier photographs with slight changes in the accompanying text, and give, in addition, a new series of photographs of ballistic, scientific, or physical interest, as well as some sterosccopic photographs and moving picture films.

The condensers were thoroughly charged by means of a static machine, the available capacity being 45,000. For making Fig. 17, a capacity of about 3500 was employed. In order to eliminate solitary shadow effects, at least two to four illumination sparks were discharged in series to the right and left of the object to be photographed, and in front of the camera.

The illumination from that spark which corresponds to the final stroke of the battery, due to self-induction, is the shortest and weakest flash.

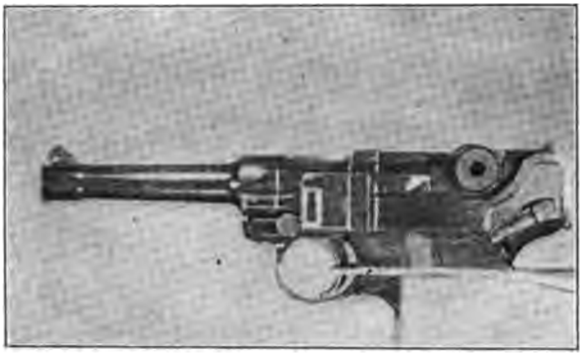


FIG. 9. 1575

In addition, small concave mirrors were placed behind the lighting area; moreover, several successful photographs were obtained by means of light projectors placed at greater distances from the object.

One or the other position of the sparking areas should be adopted according to the requirements; they will naturally vary with the methods adopted for discharging the illuminating sparks.

Fig. 9 represents the army pistol in a state of rest before firing. On the pistol housing in front of the rear end of the barrel and in rear of the breechblock may be seen vertical marks drawn with a white pencil. From the shifting of these vertical marks we may readily determine, at any instant, whether the piece has been fired, how far the breech mechanism has recoiled, etc.

Fig. 10 represents the same pistol during discharge, that is, at the moment when the bullet is 8 cm. from the muzzle. Powder gases are streaming from the muzzle, and within the powder gas may be seen the position of discharge of the electric spark.

Fig. 11 represents the same pistol at the instant when the bullet is 200 cm. from the muzzle. The extractor is partially open.

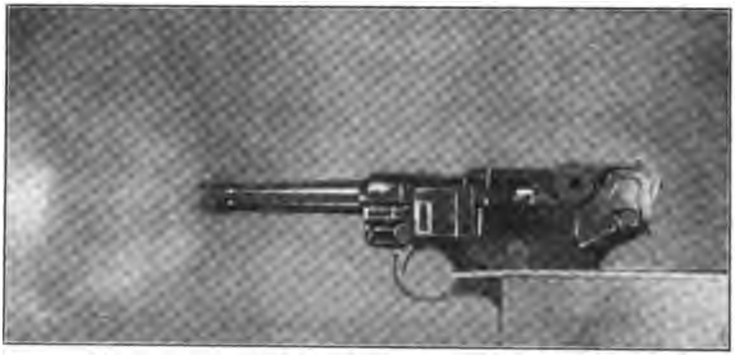


FIG. 10. 1576

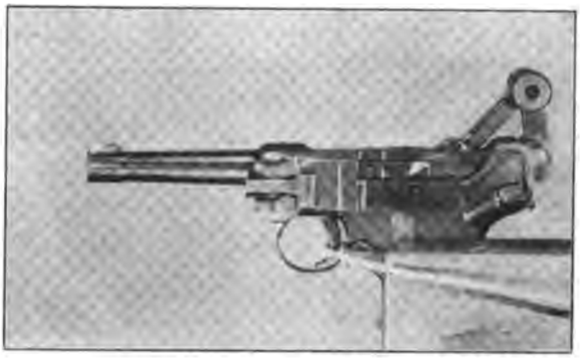


FIG. 11. 1577

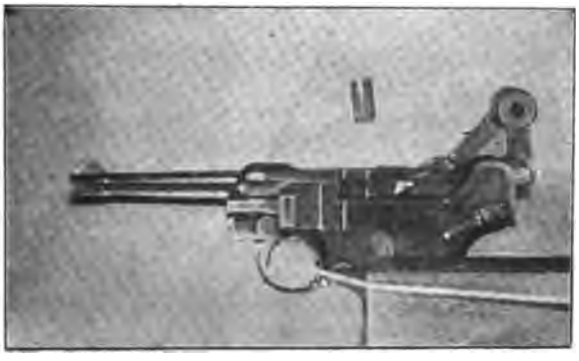
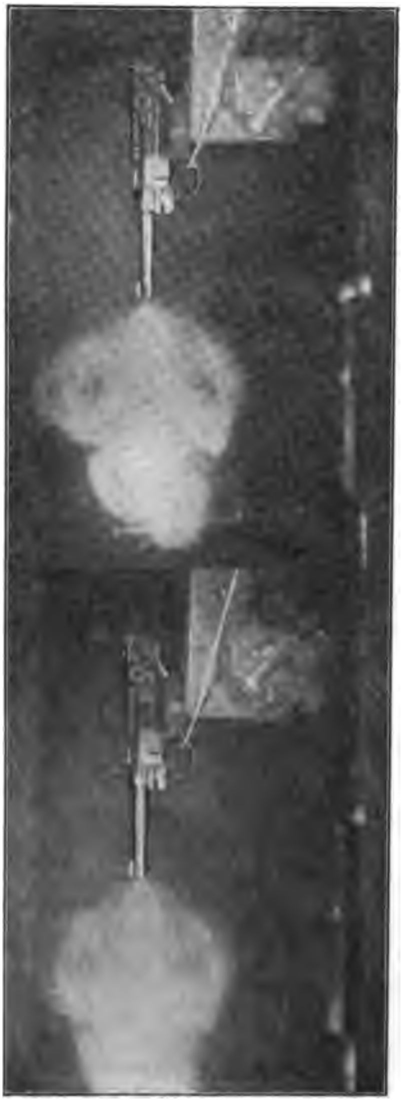
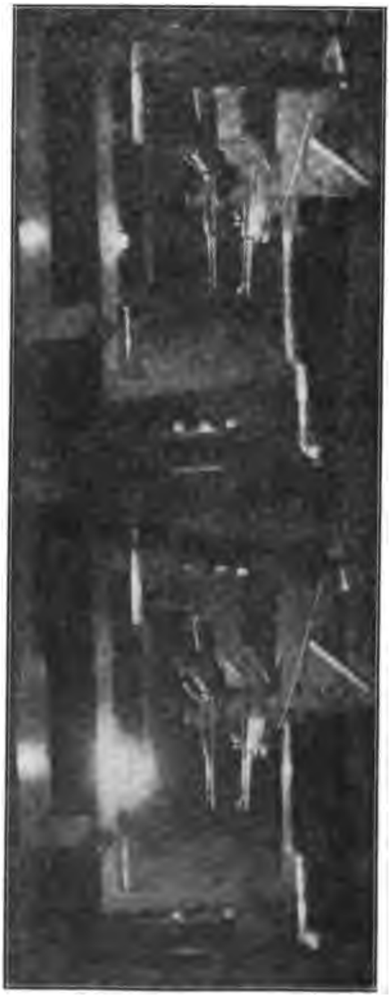


FIG. 12. 1578



1579

FIG. 13.



1580

FIG. 14.

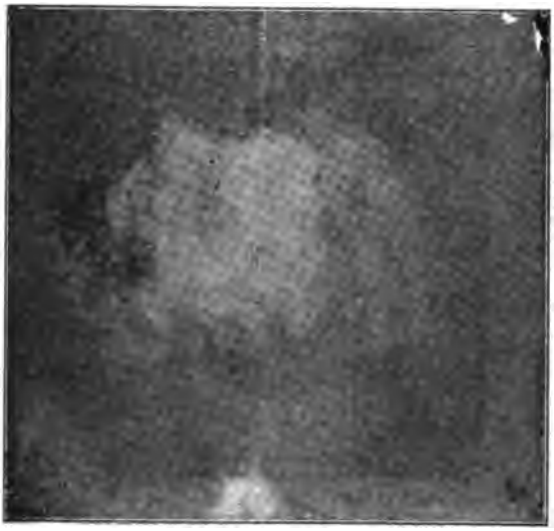


FIG. 14 I.

1581

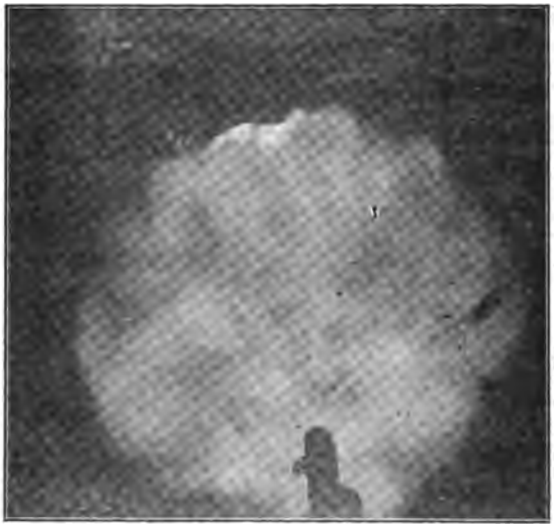
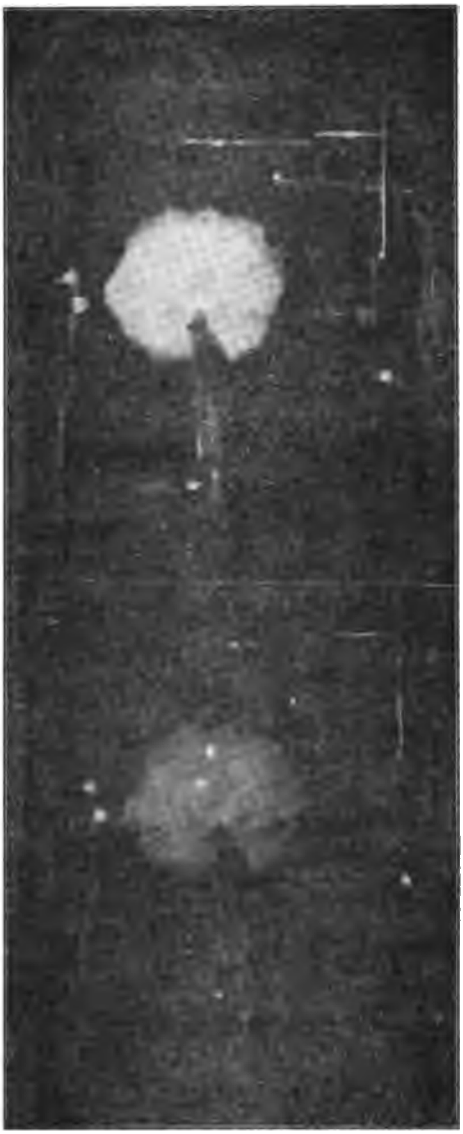


FIG. 14 II.

1582



1583

Fig. 14 III.

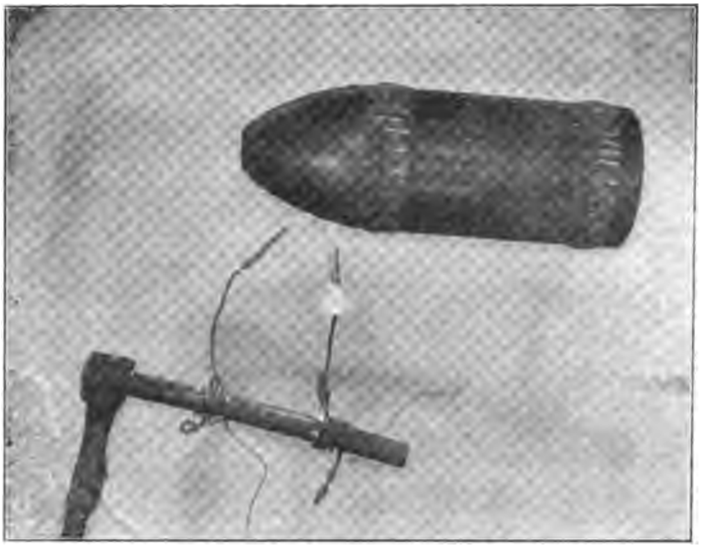


Fig. 15. 1584

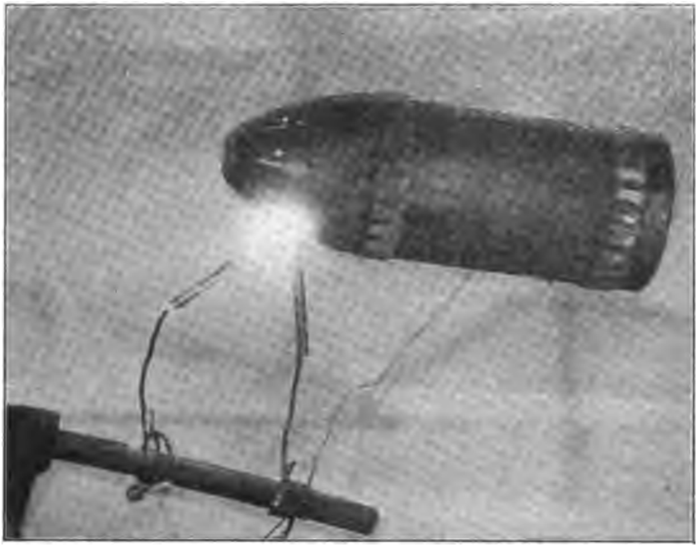


Fig. 16. 1585

Fig. 12 shows the same pistol when the bullet is 350 cm. from the muzzle. The empty cartridge case has been extracted and thrown into the air.

Fig. 13 is a double, or stereoscopic, photograph of the same pistol in firing; the powder gases are streaming from the muzzle.

Fig. 14 is a double, or stereoscopic, photograph of the same pistol in firing and its reflected image. In this, not only the pistol itself, but its reverse reflection in the mirror is visible, so that we may observe at the same instant both sides of the weapon. Such photographs have a peculiar value when we are dealing with an automatic arm, because from the front side the action of the extractor is followed with great difficulty. They are also of value in the case of small projectiles, when measuring the rotation of the projectile, its oscillations, etc.

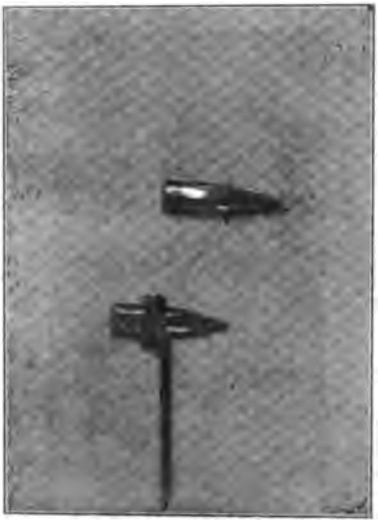


Fig. 17. 1586

Fig. 11 I shows the blast of the black powder gas at the muzzle of the small arm, Model 71, seen from the front. The larger volume of the powder gas is expanding in the form of a mushroom, while in front of this mushroom may be seen that portion of the gas which has been drawn forward by the bullet. By its form the mushroom clearly shows how the rifling has affected it. The several bright lines are the trajectories of the burning powder grains.

Fig. 14 II shows the same taken from the rear, and to one side.

Fig. 14 III is a stereoscopic, or double, photograph of the same phenomena. Examination with the stereoscope affords an exceedingly realistic view of the form of the mushroom and the trajectories of the burning powder grains. For this reason, it may be remarked, many photographs of small shot (not reproduced here) were obtained by stereoscopic methods. Stereoscopic examination of the shot sheaf permitted such an accurate separation of the individual shot in the direction of the three dimensions, that it was found possible, by means of the stereoscopic scale, to determine not only

the extent of separation of the flying shot, but also, from many successive photographs, the reduction in velocity and the rotation of the individual shot. It is probably feasible by such methods to solve many problems which are at present shrouded in mystery. We hope to recur to these matters.

Fig. 15 is an old Mörser bullet in flight. The impressions of the rifling are plainly visible in the lead bands. The point of discharge of the electric spark is behind the projectile.

Fig. 16 represents the same bullet; the point of discharge of the spark is at the lower side of the bullet. Upon the head of the bullet straight lines were drawn and numbered. From the sharpness of definition of these marks in the photograph, it is to be inferred that it is feasible, by taking two photographs of the same bullet, at the beginning and at the end of a measured distance, and employing a method for discharging the sparks not readily disturbed by the motion of the projectile, to measure the number of turns with very satisfactory accuracy.

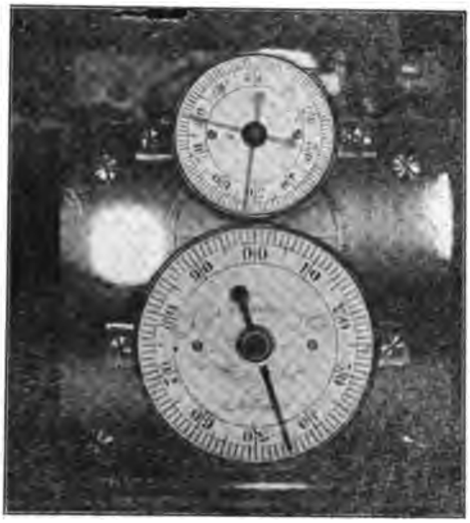


FIG. 18. 1587

Fig. 17 is the infantry bullet in flight at a distance of about 2 m. from the muzzle. The impressions of the rifling are plainly visible in the negative. We are thus in a position to ascertain whether the projectile follows the rifling or not. The picture shows, beside the bullet in flight, one of similar characteristics at rest. Comparing the length of the bullet in flight with that of the one at rest, we are in a position, the velocity of the bullet and its true length being known, to determine the length of time required for making the image on the plate in lighting by means of the electric spark, or at least to obtain a superior limit for the lighting interval. This determination naturally applies only to the special conditions under which the photograph was made; that is to say, for a spark light of definite capacity and length of
r diffusely reflected and passing through a lens. Two separate determ-
ıs gave the following values: for a capacity of 45,000 the lighting

interval was 0.4 millionths of a second; for a capacity of 3500 and another projectile, the lighting interval was from 0.19 to 0.13 millionths of a second. For the latter figure the details were as follows: lengthening of the picture, determined by a projection apparatus and Zeis scale, 16.1 − 16.0 = 0.10 cm.; photographic reduction, 1.735 to 1; that is to say, the apparent lengthening of the projectile is to multiplied by 1.735 mm. to determine its true value. The velocity of flight is 890 m.-sec.; and the lighting interval is $\frac{0.1735}{1000 \times 890}$ = 0.19 millionths of a second; by measuring the same negative with a microscope the interval is found to be 0.13 millionths of a second.

Fig. 18 shows the dial of a Hipp's clock, with two exposures on the same negative, while the clock was going. The first illumination was effected by means of a projectile of Model 88, completing, in its flight, an electric circuit by connecting two sheets of tin-foil near the muzzle of the gun; and the second illumination occurred when the same projectile after a further travel of 45.48 m. connected two other sheets of tin-foil. The time of flight of the Model 88 bullet and the mean velocity may now be determined as follows: The long hand has passed across the graduation mark numbered 45. One edge of the small hand has in the same time advanced from 79.6 through the zero to the position 52.6 (the reading should be obtained by enlarging the negative with a projecting apparatus, when the figures after the decimal point cannot be in error more than a single unit). The two readings of the clock are then 4479.6 and 4552.6, and the time of flight is 4.5526 − 4.4796 = 0.0730 seconds, according to the Hipp's clock. The test of the Hipp's clock by means of an ordinary clock showed that 20 seconds true time was 20.085 seconds by the Hipp's clock. The time of flight of the projectile in true time is, therefore, $0.073 \times \frac{20}{20.085} = 0.727$ seconds. The measured travel

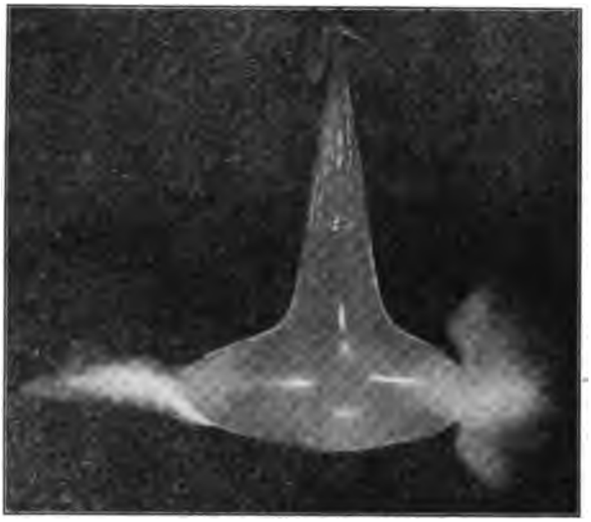


FIG. 19. 1588

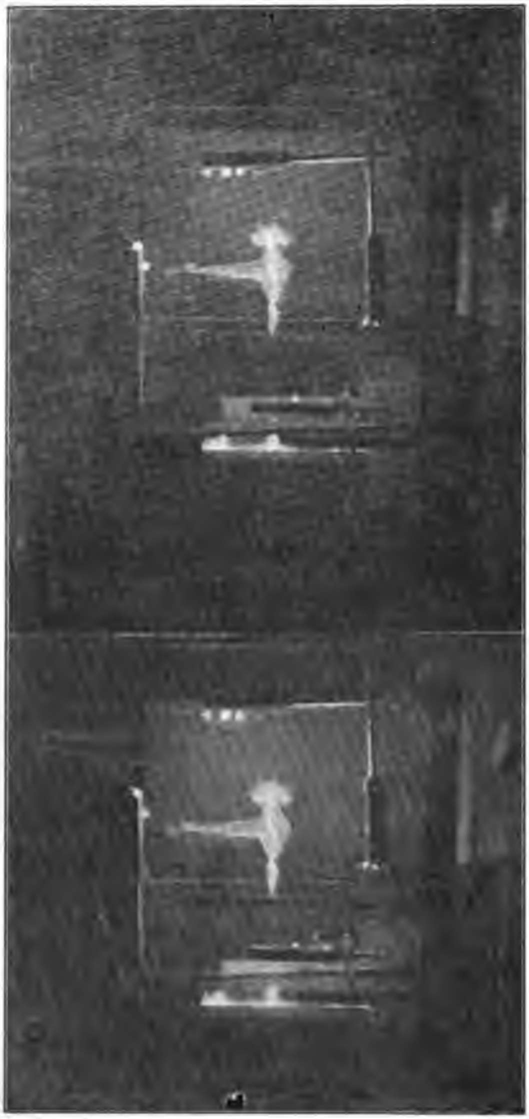


FIG. 20.

1589

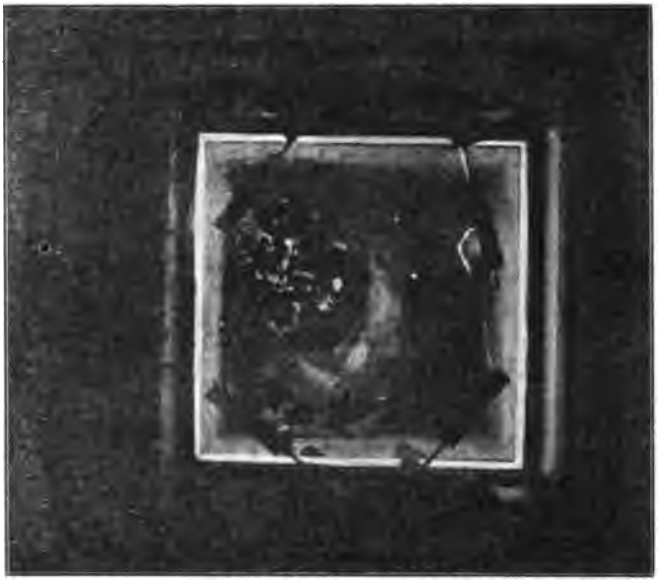


FIG. 22.

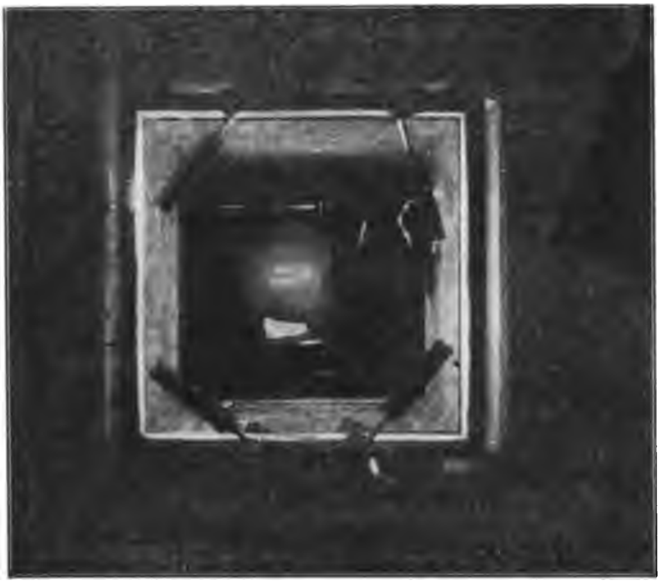


FIG. 21.

1592

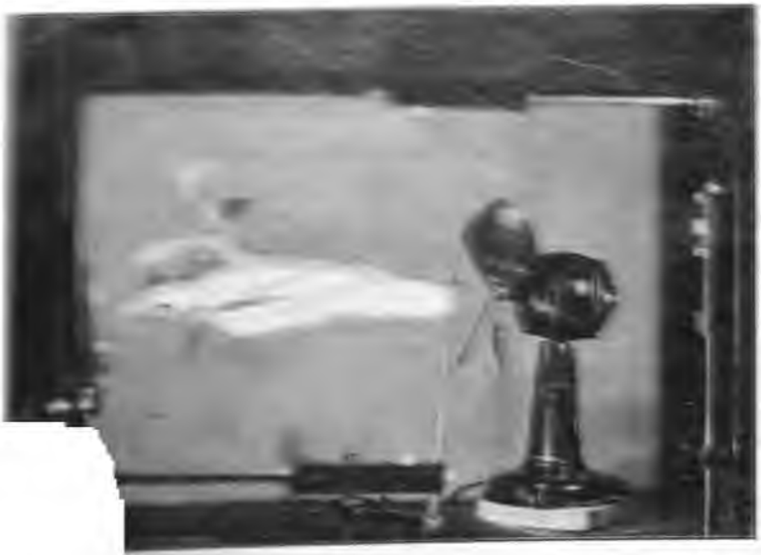


FIG. 24.

1593

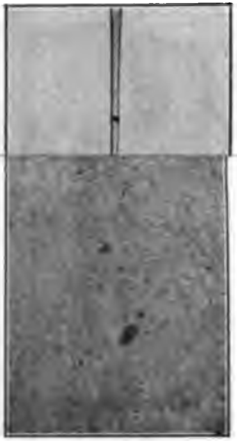


FIG. 26. 1495

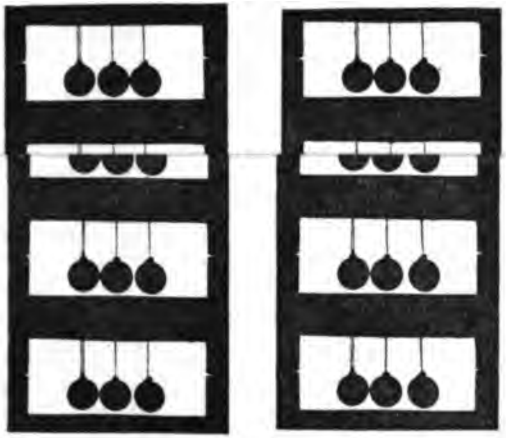


FIG. 27. 1596

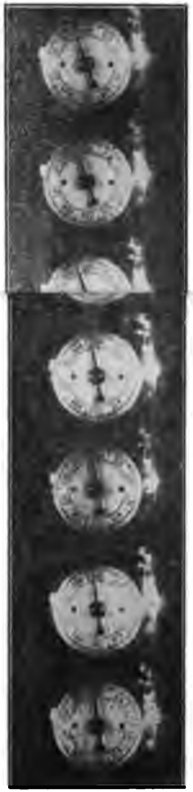


FIG. 28. 1597

FIG. 26. 1495

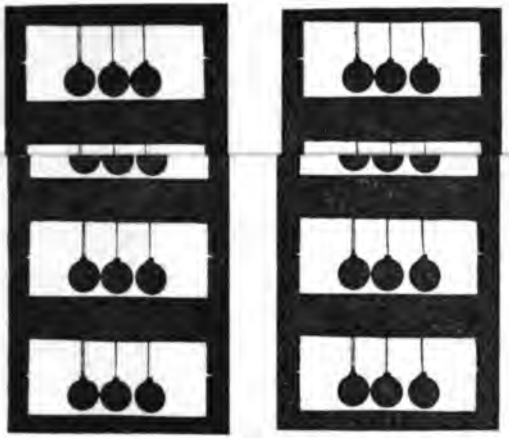


FIG. 27. 1596

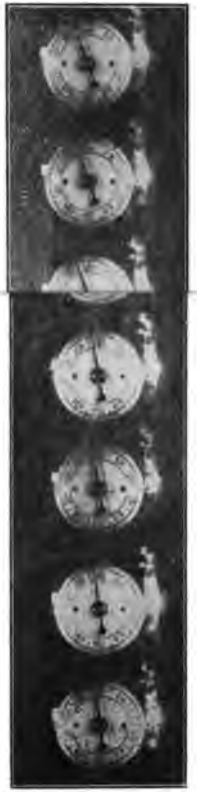


FIG. 28. 1597

being 45.58 m., the mean velocity is $45.58 \div 0.0727 = V_{25} = 627.0$ m.-sec. According to A. Burgsdorff the mean velocity of the bullet Model 88, is $V_3 = 640$ m.-sec.; while the mean velocity of the same bullet determined at an earlier date in the Ballistic Laboratory was $V_{25} = 624.7$ to 627.0 m.-sec. We may therefore conclude that the deduced value, $V_{25} = 627.0$ m.-sec., is thoroughly established for this individual bullet by the several methods of determination. But it is far from our intention to substitute for the established practice a new method of measuring the velocities of projectiles; it is better to restrict the method to laboratory use exclusively.

Fig. 19 shows the bursting effect of the S-bullet in perforating a freely suspended rubber bulb filled with water. The bullet has perforated the rubber bulb and is passing out of the field of view to the left. The rubber covering has been sharply distended in the direction of the projectile, and will subsequently be torn completely apart, the water being thrown in all directions. (The object of this and similar photographs is a reply to such questions as those asked us by the celebrated army surgeon Doctor von Bruns in regard to the ways and means by which the head of a bullet is deformed in perforating soft parts of the human body.)

Fig. 20 is a stereoscopic photograph of the same.

Figs. 21 and 22 show the explosive effect of the S-bullet on moist clay. Within a wooden box (Fig. 21) a ball of moist clay is placed in the line of fire; close behind the clay ball are the points of discharge of the electric sparks; the four illuminating spark-plugs are connected by short conductors with the condensers and discharged one after the other; they are visible at the four corners of the box. In Fig. 22 is shown the same clay ball as it appears shattered after perforation by the S-bullet, fragments being scattered in all directions, but remaining constant in volume. These fragments were thrown with great force against the walls of the box toward the gun and to the rear.

Fig. 23 is a stereoscopic photograph of a ricochet on the water.

Fig. 24 is a fan in rapid revolution. During the incredibly short period of illumination the fan appears stationary. That it is actually revolving is shown by its effect on the paper strips.

Fig. 25 shows falling drops of water. The phenomena well known to natural science concerning the separation into single drops of the steady stream and the periodical formation of the falling drops are accurately reproduced in this photograph.

Fig. 26 shows the same phenomena for quicksilver from a small opening, under slight pressure.

Figs. 27 and 28 are moving-picture films made with a time interval of 1/5000 of a second from picture to picture.

In order to illustrate the characteristic difference between kinetoscopic shadow pictures and kinetoscopic photographs lighted from the front, there is given in Fig. 27 a section of a moving picture film made with light from the background, that is to say a series of shadow photographs. Two steel balls are so suspended that when they are at rest they lie close together. A third ball swings from the left and strikes against the first ball at rest. After the blow, the first, or middle, ball remains at rest, even after the full stroke; the second ball formerly at rest swings off to the right. The whole film, which consists of 300 pictures, was obtained with concave mirror and objective by Mach's characteristic methods. One picture follows the other at the rate of 1/2500 seconds. Such serial shadow pictures are comparatively easy to obtain with the ballistic kinetoscope of the laboratory where is obtainable sufficient light, shining directly from the rear, past the balls, and falling on the objective lens of the camera. It is vastly more difficult, however, to obtain such serial negatives with the ballistic kinetoscopic methods in common use, employing frontal illumination; that is, using the light reflected into the object lens of the camera from the face of the object to be photographed. It is practicable to obtain such pictures of a moving object at all only by intensely concentrating the electric spark light. As an example of series pictures by frontal illumination, we have selected an object of which it is impossible to obtain a kinetoscopic photograph in silhouette, that is, the movement of the small hand of a Hipp's clock over the attached (indistinctly seen) dial (Fig. 28). We can follow the progress of the hand in the eighteen successive pictures, here reproduced.

In fifteen exposures the hand has advanced over three divisions; and, every division corresponding to 1/1000 sec. of time, it follows that one picture succeeds another every 1/5000 seconds.

It is intended to pursue the subject of taking series photographs by frontal illumination further. In this connection we may state that Herr H. Boas in Berlin has lately succeeded, by using cheaper material, in building condensers of considerable capacity, which, in comparison with the Leyden jars formerly used, have little self-induction, which makes it possible to obtain single sparks of great energy and sufficiently small lighting interval.

—*Zeitschrift für das Gesamte Schiess-und Sprengstoffwesen.*

◆ ◆ ◆

## ON THE PRECISION OF COINCIDENCE RANGE-FINDERS

Translated from the French of Captain L. Graux, of the
French Artillery

It is proposed in this article, not to set forth the well known principle of coincidence range-finders nor to describe the different models in use in France or other countries, but to investigate the precision of which these instruments are capable, and then to determine the best manner of employing them.

However, what is to be said will apply to all coincidence range-finders; that is, to all range-finders of which the principle is the observation of the parallax of the object of which the range is desired from the two ends of a base line of known length lying perpendicular to the line of sight.

A beginning will be made with certain definitions of primary importance in the theoretical study of range-finders.

### *Acuity of Vision*

Let two black lines, parallel and separated about 1 mm. (.04 in.), be drawn on a sheet of white paper and the paper fastened on the wall. When one is near enough to the lines, the two are clearly distinguished; but let one gradually increase the distance between oneself and the lines: at a certain distance the lines will appear to blend. If the interval by which the two lines are separated be doubled or trebled, the distance at which they appear to blend will also be doubled or trebled. In other words, the two lines will blend when the interval by which they are separated is seen at an angle equal to or less than a certain value. The *acuity of vision* of the observer is said to be greater accordingly as that angle is smaller. For the normal eye, the angle is about 1 minute, or $\frac{1}{3000}$; that is to say, two lines separated by 1 mm. (.04 in.) cease to be seen separate from each other by the normal eye at a distance of 3 m. (9.84 ft.).

As a measure of acuity of vision, may be taken the figure which expresses the distance at which the interval between two lines ceases to be visible, the interval being taken as the unit in the measurement of the distance. With that definition, the acuity of vision of the normal eye is 3000; and, in general, if the smallest angle which an eye can separate is $\frac{1}{\mu}$ radians the acuity of vision is $\mu$.

As is the case with all physiological quantities, the acuity of vision of a given person is not capable of precise measurement: even when the observer operates without eye fatigue and under fixed conditions of light, two successive measurements will generally give for the minimum angle that the eye can separate two values which, while approximately, are not exactly, the same. For example, for the normal eye will be found for that angle the value of 1 minute, or $\frac{1}{3000}$, to within $\frac{1}{10}$; that is to say, the error in the measurement of the angle, even if the eye is not fatigued and the conditions of light are not changed, may reach a value of $\frac{1}{30,000}$, and so the distance at which two lines separated by 1 mm. (.04 in.) cease to be seen separately may vary from 2.727 m. to 3.333 m. (from 8.944 ft. to 10.932 ft.).*

If the eye is fatigued, acuity of vision is less than when the eye is not fatigued. Also, acuity of vision varies with the illumination of the object, being less accordingly as the illumination is less.

### *Accuracy and Precision*

If a large number of measurements of the range to an object are made, the *accuracy* of the instrument is indicated by the difference between the true range and the mean of the *n* measurements given by the instrument. The *precision* of the instrument is indicated by the mean variation, or the probable variation, of the *n* measurements from the mean of those measurements.

## I

## INVESTIGATION OF THE PRECISION OF COINCIDENCE RANGE-FINDERS

The causes which affect the accuracy and the precision of coincidence range-finders are numerous:

Eyesight and skill of the operator;
Faulty initial adjustment of the instrument;
Derangement of the range-finder owing to variations of temperature;
Precision in the reading of ranges, etc.

Of those various causes, only one will be studied—the operator's eye-

---

* In general, the minimum angle, $\frac{1}{\mu}$, which the eye can separate will be determined to within $\frac{1}{n}$, so the value can vary between

$$\frac{1}{\mu}\left(1-\frac{1}{n}\right) \text{ and } \frac{1}{\mu}\left(1+\frac{1}{n}\right)$$

sight. It is assumed that the instrument is perfect and perfectly adjusted, and that no error occurs in reading the range; so we are concerned only with the errors that are due to the imperfection of the human eye.*

In order to lend clearness to the discussion, the method of successive approximations is adopted.

There will be examined first the case of an eye endowed with an infinite acuity of vision; then it will be assumed that the observer's acuity of vision is finite, but invariable; and finally, hypothesis will be made, in agreement with the actual case, of an eye endowed with an acuity of vision that is subject to slight variation from one observation to another.

### 1. THE CASE OF AN EYE OF INFINITE ACUITY OF VISION

When the range adjusting mark is opposite the "infinity" line of the scale, the two images of a very distant object, such as a star, are blended; the two images of an object at a range $D$ are separately distinct, and the interval separating them is seen by the observer through the angle $G\alpha$, $G$ being the power of the instrument, and $\alpha$ the parallax $\frac{B}{D}$ of the object at the range $D$ observed from the two ends of the range-finder's base.

If it is desired to bring the two images of this object into coincidence, it is done by means of the milled screw controlling the movable prism and the range scale, which is in one piece with the prism; in this way the angular displacement of the two images is made to vary by an amount proportional to the movement of the movable prism. When coincidence has been obtained, the prism has displaced one of the images relatively to the other to the extent of an angle $G\alpha$, or $G\frac{B}{D}$; the scale is so graduated that, for this position of the prism, the range adjusting mark is opposite the graduation $D$.

If, as has been assumed, the range-finder is in adjustment, it will give the exact range $D$.

### 2. THE CASE OF AN EYE OF FINITE, BUT INVARIABLE, ACUITY OF VISION

In this case, in order to effect *apparent* conicidence of the two images of an object at the range $D$, it is not necessary to move the movable prism from the "infinity" mark till one of the images has, relatively to the other, been displaced through an angle exactly equal to $G\alpha$; for apparent coincidence will be effected by a movement through an angular displacement $G\alpha'$, such that

$$G\alpha' - G\alpha < \frac{1}{\mu}$$

$\mu$ being the observer's acuity of vision.

If $d$ is the error made, the preceding inequality may be written:

$$G\frac{B}{D+d} - G\frac{B}{D} < \frac{1}{\mu}$$

Neglecting $d$ in comparison with $D$, there follows:

$$d < \frac{D^2}{\mu\, B\, G}(\dagger)$$

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* The effect of faulty adjustment of the instrument will be considered briefly.

† We shall see later, page 133, to what extent it is proper to neglect $d$ in comparison with $D$.

Hence, in measuring the range by a single coincidence without special precautions, there may enter an error the maximum value of which is $\delta = \frac{D^2}{\mu\ B\ G}$. For a given range, this maximum error is smaller accordingly as the base line is longer and the power of the telescope greater. For a given range-finder, the maximum error increases with the square of the range; and the maximum proportional error,

$$\epsilon = \frac{D}{\mu\ B\ G},$$

increases with the range. Other things being constant, the maximum error is smaller accordingly as the acuity of vision, $\mu$, is greater.

There have been calculated, for the normal eye of 3000 acuity, values of $\delta$ and $\epsilon$ at different ranges for range-finders of 0.66 m. (2.15 ft.), $G=14$; 0.80 m. (2.62 ft.), $G=14$; 1 m. (3.28 ft.), $G=17$; 1.37 m. (4.49 ft.), $G=17$; and 2 m. (6.56 ft.), $G=25$. Values have been calculated up to a range of 8000 m. (8749 yds.) for the 2-m. (6.56 ft.) and 1.37 m. (4.49 ft.) range-finders; up to 6000 m. (6562 yds.) for the 1-m. (3.28 ft.) and 0.80-m. (2.62 ft.); and to 4000 m. (4374 yds.) for the 0.66-m. (2.15 ft.) range-finder.

The errors $\delta$ thus calculated are accidental errors; that is to say, they sometimes occur in one direction and at other times in the opposite; they indicate the precision with which a perfect range-finder, perfectly adjusted, measures a range, when the measurement is made by a single coincidence and without special precautions.

Only the 2-m. (6.56 ft.) range-finder, with telescope of 25 power, gives permissible errors at a range of 6000 m. (6562 yds.). But a range-finder of that size is not easily transported; while also, for the measurement of ranges to terrestrial objects, a power of 25 is too great, because of the faulty definition that results. Therefore, as long as the method of using the instrument which gave such errors was the only method considered, the use of the coincidence range-finder as a portable field range-finder was in disfavor.

Naturally, the makers and users of range-finders were led to seek a method of measurement that would make it possible to eliminate the accidental error $\delta$.

Their investigation resulted in the method that is standard to-day, which is known as the *over and short*, or *bracketing*, method.

Quoting the instructions relative to the use of the range-finder, that method is as follows: "Turn the screw of the movable prism until the upper image appears to unite with the lower, then continue to turn in the same direction in such a way as to cause the upper image to extend beyond the lower a scarcely appreciable distance. Note the range.

"Turn the screw of the movable prism in the opposite direction in such a way as to cause the image to extend slightly on the other side. Note the range.

"The mean of the two observations will be the desired range.

"With a little practice, it is possible for one to dispense with noting the two ranges of the bracket for the purpose of getting their mean; it is sufficient, after having made the bracket, to bring the prism back to the mean position and then to read the range."

If, in the first method of bracketing, the errors of reading are neglected and, in the second, the error made in bringing the prism back to the mean,

## TABLE A

| Range-finder | Ranges | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1000 m. (1094 yds.) | | 2000 m. (2187 yds.) | | 4000 m. (4374 yds.) | | 6000 m. (6562 yds.) | | 8000 m. (8749 yds.) | |
| | $\delta$ | $\epsilon$ | $\delta$ | $\epsilon$ | $\delta$ | $\epsilon$ | $\delta$ | $\epsilon$ | $\delta$ | $\epsilon$ |
| 0.66 m.<br>(2.15 ft.) | 36 m.<br>(39.24 yds.) | $\frac{1}{28}$ | 144 m.<br>(156.96 yds.) | $\frac{1}{14}$ | 577 m.<br>(628.93 yds.) | $\frac{1}{7}$ | ....<br>.... | ..<br>.. | ....<br>.... | ..<br>.. |
| 0.80 m.<br>(2.62 ft.) | 30 m.<br>(32.7 yds.) | $\frac{1}{34}$ | 119 m.<br>(129.71 yds.) | $\frac{1}{17}$ | 476 m.<br>(518.84 yds.) | $\frac{1}{8}$ | 1071 m.<br>(1167.39 yds.) | $\frac{1}{6}$ | ....<br>.... | ..<br>.. |
| 1.00 m.<br>(3.28 ft.) | 19 m.<br>(20.71 yds.) | $\frac{1}{53}$ | 78 m.<br>(85.02 yds.) | $\frac{1}{25}$ | 314 m.<br>(342.26 yds.) | $\frac{1}{13}$ | 706 m.<br>(769.54 m.) | $\frac{1}{9}$ | ....<br>.... | ..<br>.. |
| 1.37 m.<br>(4.49 ft.) | 14 m.<br>(15.26 yds.) | $\frac{1}{70}$ | 57 m.<br>(62.13 yds.) | $\frac{1}{35}$ | 230 m.<br>(250.70 yds.) | $\frac{1}{17}$ | 510 m.<br>(555.90 yds.) | $\frac{1}{12}$ | 916 m.<br>(998.44 yds.) | $\frac{1}{9}$ |
| 2.00 m.<br>(6.56 ft.) | 7 m.<br>(7.63 yds.) | $\frac{1}{150}$ | 27 m.<br>(29.43 yds.) | $\frac{1}{75}$ | 107 m.<br>(116.63 yds.) | $\frac{1}{37}$ | 240 m.<br>(261.6 yds.) | $\frac{1}{25}$ | 426 m.<br>(464.34 yds.) | $\frac{1}{19}$ |

position, it is evident that the two methods will give the same result.* The range corresponding to one of the limits of the bracket is $D \pm \delta$, and that corresponding to the other is $D \mp \delta$, since those two limits of the bracket correspond to the two positions of the movable prism in which apparent coincidence begins or ends. The mean of the two ranges is

$$\tfrac{1}{2}\,(D \pm \delta + D \mp \delta), \text{ or } D.$$

It is the same in the second method of bracketing.

### 3. THE CASE OF AN EYE OF FINITE ACUITY OF VISION THAT IS SUBJECT TO VARIATION FROM ONE OBSERVATION TO ANOTHER

If the examination of the bracketing method is taken up in this case, the following results are gotten.

In the case just preceding, the maximum error $\delta$ at the two extremes of the bracket was found to be $\frac{D^2}{\mu\, B\, G}$. In the present case, that maximum error may have any value between $\frac{D^2}{\mu\, B\, G}\left(1 - \frac{1}{n}\right)$ and $\frac{D^2}{\mu\, B\, G}\left(1 + \frac{1}{n}\right)$; so the ranges $D_1$ and $D_2$, which correspond to the two limits of the bracket may have, respectively, any value between:

$$D \mp \frac{D^2}{\mu\, B\, G}\left(1 - \frac{1}{n}\right) \text{ and } D \mp \frac{D^2}{\mu\, B\, G}\left(1 + \frac{1}{n}\right) \text{ for } D_1$$

and

$$D \pm \frac{D^2}{\mu\, B\, G}\left(1 - \frac{1}{n}\right) \text{ and } D \pm \frac{D^2}{\mu\, B\, G}\left(1 + \frac{1}{n}\right) \text{ for } D_2$$

Hence, the mean fraction $\frac{D_1 + D_2}{2}$ may have any value between

$$D - \frac{D^2}{n\, \mu\, B\, G} \text{ and } D + \frac{D^2}{n\, \mu\, B\, G}$$

Consequently, the bracketing method gives the range $D$ with a maximum error of $\frac{D^2}{n\, \mu\, B\, G}$, that is to say $n$ times smaller than the maximum error corresponding to the simple coincidence method.

In the case of the normal eye, $n$ is equal to about ten; so the precision of the bracketing method, for the normal eye, is ten times greater than that of the simple coincidence method.

Writing

$$\delta_1 = \frac{D^2}{n\, \mu\, B\, G} \qquad \epsilon_1 = \frac{D}{n\, \mu\, B\, G}$$

for the range-finders previously referred to, there is gotten the following table:

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* Provided that, between the two positions of the scale corresponding to the two limits of the bracket, the graduations of the scale are uniform; and, since $\delta$ is small in comparison with $D$, this condition is practically realized.

## TABLE B

| Range-finder | Ranges | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1000 m. (1094 yds.) | | 2000 m. (2187 yds.) | | 4000 m. (4374 yds.) | | 6000 m. (6562 yds.) | | 8000 m. (8749 yds.) | |
| | $\delta_1$ | $\epsilon_1$ | $\delta_1$ | $\epsilon_1$ | $\delta_1$ | $\epsilon_1$ | $\delta_1$ | $\epsilon_1$ | $\delta_1$ | $\epsilon_1$ |
| 0.66 m.<br>(2.15 ft.) | 4 m.<br>(4.37 yds.) | $\frac{1}{280}$ | 14 m.<br>(15.31 yds.) | $\frac{1}{140}$ | 58 m.<br>(63.43 yds.) | $\frac{1}{70}$ | ....<br>.... | ..<br>.. | ....<br>.... | ..<br>.. |
| 0.80 m.<br>(2.62 ft.) | 3 m.<br>(3.28 yds.) | $\frac{1}{340}$ | 12 m.<br>(13.12 yds.) | $\frac{1}{170}$ | 48 m.<br>(52.49 yds.) | $\frac{1}{80}$ | 107 m.<br>(117.01 yds.) | $\frac{1}{60}$ | ....<br>.... | ..<br>.. |
| 1.00 m.<br>(3.28 ft.) | 2 m.<br>(2.19 yds.) | $\frac{1}{530}$ | 8 m.<br>(8.74 yds.) | $\frac{1}{250}$ | 31 m.<br>(33.90 yds.) | $\frac{1}{130}$ | 71 m.<br>(77.64 yds.) | $\frac{1}{90}$ | ....<br>.... | ..<br>.. |
| 1.37 m.<br>(4.49 ft.) | 1 m.<br>(1.09 yds.) | $\frac{1}{700}$ | 6 m.<br>(6.56 yds.) | $\frac{1}{350}$ | 23 m.<br>(25.15 yds.) | $\frac{1}{170}$ | 51 m.<br>(55.77 yds.) | $\frac{1}{120}$ | 92 m.<br>(100.61 yds.) | $\frac{1}{90}$ |
| 2.00 m.<br>(6.56 ft.) | 1 m.<br>(1.09 yds.) | $\frac{1}{1500}$ | 3 m.<br>(3.28 yds.) | $\frac{1}{750}$ | 11 m.<br>(12.03 yds.) | $\frac{1}{370}$ | 24 m.<br>(26.24 yds.) | $\frac{1}{250}$ | 43 m.<br>(47.02 yds.) | $\frac{1}{190}$ |

### 4. THE EFFECT OF AN ERROR IN ADJUSTMENT OF THE INSTRUMENT

In the manufacture of a range-finder are included certain adjustments, which are called *maker's adjustments;* and at the time of using the range-finder to measure ranges, the operator begins by making an adjustment, which is called the *operator's adjustment.*

It will be assumed that the instrument is well built, that is to say, that the maker's adjustments are perfect; and investigation will be made of the effect on ranges measured of an imperfect operator's adjustment.

In order to make his adjustment, the operator uses either a point at an infinite range or a point at a known range. He sets the range on the scale, setting at the "infinity" graduation, if using a point at an infinite range. If the images do not coincide, he turns the adjusting screw till exact coincidence is obtained, the movable prism and the range scale remaining fixed. (By "exact coincidence" is meant the mean of the two limits of coincidence; for if this method is not followed, there will be an error of adjustment of which the effect is to introduce into the reading of ranges a systematic error that may be as large as $\delta$ (see Table A, page 130). To obtain a satisfactory adjustment, it is necessary to turn the adjusting screw till the reading of the range to the adjusting point by the bracketing method gives the exact range of that point (the infinity graduation, if the point is at an infinite distance). When that has been accomplished, the maximum value of the systematic error is equal to $\delta_1$ (Table B, page 132).

Hence, it is seen that in reading a range, the maximum error that can be committed by the bracketing method is equal to the sum of the systematic error and the accidental error, or $2\delta_1$.

### DISCUSSION OF A SYSTEMATIC ERROR

In the inequality determined in the second case, $d$ was neglected in comparison with $D$ (page 128). Let us now determine to what extent that approximation is justified.

Let $d_1$ and $d_2$ be, respectively, the errors committed when, in the first method of bracketing, the observer determines the limit of coincidence that corresponds to a short reading and that which corresponds to an over. These values, $d_1$ and $d_2$, are given by the two equations:

$$G\frac{B}{D-d_1} - G\frac{B}{D} = \frac{1}{\mu}$$

$$G\frac{B}{D} - G\frac{B}{D+d_2} = \frac{1}{\mu}$$

From which are gotten:

$$d_1 = \frac{D\epsilon}{1+\epsilon}$$

$$d_2 = \frac{D\epsilon}{1-\epsilon}$$

The ranges read at the two limits of coincidence will then be:

$$D_1 = D - \frac{D\epsilon}{1+\epsilon}$$

$$D_2 = D + \frac{D\epsilon}{1-\epsilon}$$

Their mean will be:

$$\Delta = \frac{D_1 + D_2}{2} = D + \frac{D\epsilon^2}{1-\epsilon^2}$$

The mean is, then, not exactly equal to $D$, but is always greater by a quantity,

$$\theta = \frac{D\epsilon^2}{1-\epsilon^2} = \frac{D^3}{\mu^2 B^2 G^2 \left(1 - \frac{D^2}{\mu^2 G^2 B^2}\right)}$$

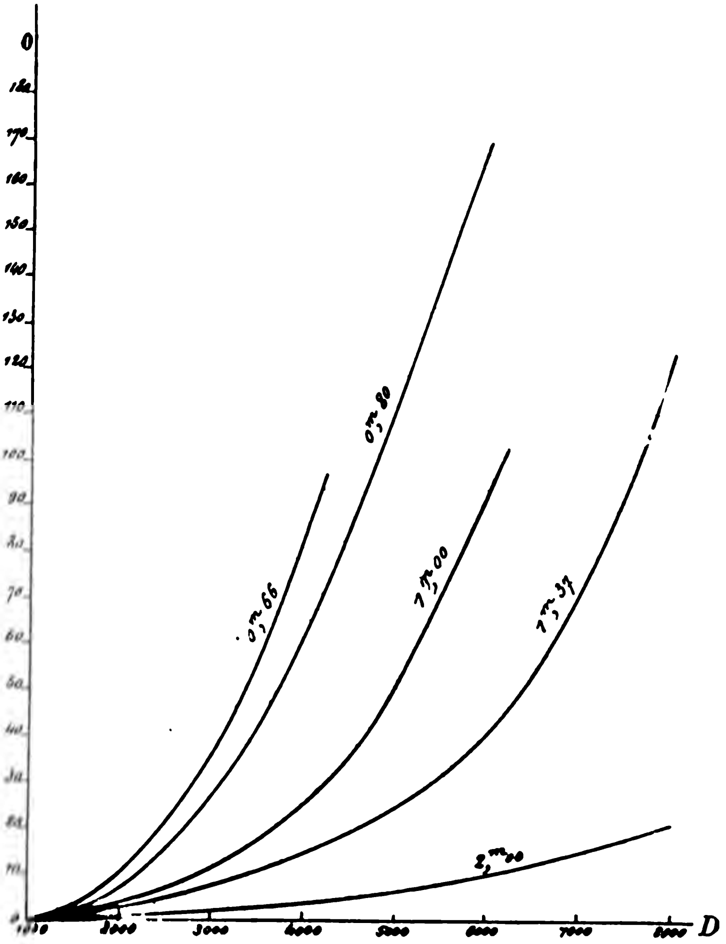

FIG. 1. 1598

Curve of values of $\theta$ (acuity of vision = 3000).

In other words, an observer using a range-finder graduated and adjusted for an eye of infinite acuity of vision, will find, by the double-reading bracketing method, a range systematically greater than the true range, and the systematic error $\theta$ will be greater:

1. Accordingly as the base is shorter.
2. Accordingly as the magnification is smaller.
3. Accordingly as the acuity of vision of the observer is weaker.
4. Accordingly as the range to the object is greater.

The error $\theta$ increases more rapidly than the cube of the range.

The curves of Fig. 1 give, for the range-finders taken as examples, the values of $\theta$ as a function of the range.

In table C are given a certain number of values of $\theta$ for different ranges.

Table C

| Range-finders | Ranges | | | | |
|---|---|---|---|---|---|
| | 1000 m. (1094 yds.) | 2000 m. (2187 yds.) | 4000 m. (4374 yds.) | 6000 m. (6562 yds.) | 8000 m. (8749 yds.) |
| 0.66 m. (2.15 ft.) | 1 m. (1.1 yds.) | 10 m. (10.9 yds.) | 85 m. (93 yds.) | ... ... | ... ... |
| 0.80 m. (2.62 ft.) | 1 m. (1.1 yds.) | 7 m. (7.6 yds.) | 58 m. (63.4 yds.) | 196 m. (214.4 yds.) | ... ... |
| 1.00 m. (3.28 ft.) | 0 | 3 m. (3.3 yds.) | 24 m. (26.2 yds.) | 83 m. (90.8 yds.) | ... ... |
| 1.37 m. (4.49 ft.) | 0 | 2 m. (2.2 yds.) | 13 m. (14 yds.) | 43 m. (47 yds.) | 125 m. (136.7 yds.) |
| 2.00 m. (6.56 ft.) | 0 | 0 | 3 m. (3.3 yds.) | 10 m. (10.9 yds.) | 23 m. (25.2 yds.) |

Upon comparison of Table C with Table B, it is seen that, though the systematic error $\theta$ is smaller than the accidental error $\delta_1$ at short ranges, the inverse is true at long ranges. Only the 2-meter (6.56-foot) base range-finder has at 8000 m. (8749 yds.) a systematic error that is smaller than the accidental error. It is obvious that the two errors are equal for the range

$$D = 0.1\,\mu\,B\,G(^*)$$

For the different range-finders considered, the ranges at which the two errors are equal, are:

| Range-finder | 0.66 m. (2.15 ft.) | 0.80 m. (2.62 ft.) | 1 m. (3.28 ft.) | 1.37 m. (4.49 ft.) | 2 m. (6.56 ft.) |
|---|---|---|---|---|---|
| Ranges | 2800 m. (3062 yds.) | 3350 m. (3663 yds.) | 5100 m. (5577 yds.) | 7000 m. (7655 yds.) | 15,000 m. (16,404 yds.) |

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[*] Assuming the two errors $\theta$ and $\delta_1$ to be equal, there results an equation of the second degree:

$$D^2 + n\,\mu\,BGD - \mu^2B^2G^2 = 0$$

whence,

$$D = \mu\,B\,G\left(\sqrt{\frac{n^2}{4}+1} - \frac{n}{2}\right)$$

For $n = 10$, $D = 0.1\,\mu\,BG$.

The systematic error that has just been pointed out is attributable to the fact that the scale is graduated, not in parallaxes, but in ranges. The position of the scale that corresponds to the exact range is the position midway between those that correspond, respectively, to the two limits of coincidence. We know that the movements of the image produced by the movable prism are proportional to the corresponding movements of the scale. A graduation of the scale in parallaxes, therefore, would be a graduation of equal intervals; and if there could be read on the scale the parallaxes $\alpha_1$ and $\alpha_2$ corresponding to the two limits of the bracket, their mean, $\frac{\alpha_1 + \alpha_2}{2}$, would correspond to the mean position of the scale. But, the ranges being proportional, not to the parallaxes, but to their reciprocals, the graduation in ranges is not one of equal intervals, and the range $\frac{D_1 + D_2}{2}$ is not at the middle of the interval $D_1 D_2$.

The use of the second method of bracketing eliminates the systematic error, since that method consists in bringing the prism to the mean position (that is to say, to the position corresponding to the middle of the interval $D_1 D_2$) and reading the range, after having made the bracket without reading the ranges corresponding to the limiting positions.

In the next chapter the effects of this systematic error will be studied from the point of view of use of the instrument.

## II

## Ways of Using Coincidence Range-Finders

A beginning will be made by studying the method of graduation of the scale.

It has been seen that the relative displacements of the two images caused by the movements of the prism are proportional to those movements. To be precise, in the case of a perfect range-finder, perfectly adjusted, there is proportion between the parallax of an object and the movement which must be made by an observer of infinite acuity of vision in passing from the "infinity" position of the scale to the position which gives coincidence of the two images. So if the scale is graduated in parallaxes, the graduation will be one of equal intervals, the zero corresponding to no parallax, that is to an infinite range (scale A, Fig. 2).

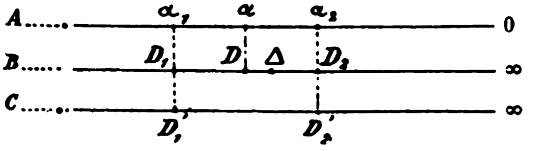

FIG. 2. 1599

In order to find a range with this scale, it is sufficient for an eye of infinite acuity of vision to effect coincidence and to read the corresponding division $\alpha$; division on a table of equivalents will give the range $D = \frac{B}{\alpha}$; if the observer's acuity of vision is finite, either of the two methods of bracketing will give the division $\alpha$, since that division is equidistant from those that correspond to the two limits of the bracket.

Now let us suppose that, in the instrument under consideration, for the scale A is substituted a scale B, graduated in ranges, so that, instead of $\alpha$ being read at all, the range $D = \frac{B}{\alpha}$ is read directly; an observer of infinite acuity of vision, after having effected coincidence, will read the range $D$ directly on the scale. Likewise, an observer of finite acuity of vision will, by the second method of bracketing, find the range $D$, for on the scale $B$ this range is at the middle of the interval between the ranges $D_1$ and $D_2$, read at the two positions corresponding to the two limits of the bracket. But, on the other hand, if this observer uses the first method of bracketing, the range found will, as we have seen, be equal to $\Delta = D + \theta$.

If inspectors adjust and test the instruments by the second method of bracketing, the manufacturer will deliver them with scales of the type B described. But, if, on the contrary, the range-finders were adjusted and tested, in inspection, by the first method of bracketing, the manufacturer would be led to adopt a scale graduation such that the mean $\frac{D_1' + D_2'}{2}$ of the readings corresponding to the two limits of the bracket would be equal to $D$ (scale C);* but, since the systematic error $\theta$ depends upon the observer's acuity of vision, such a scale could be graduated only for one given acuity of vision; for example, for the mean acuity of vision of the observers taking part in the test. Such an instrument, in use afterwards by observers of acuity of vision differing from that for which it was manufactured, would give a systematic error, both when used in the first method of bracketing and when used in the second.

In the test of any instrument, whatever its nature, it is logical to endeavor to eliminate causes of error which are not ascribable to the instrument itself. From this point of view, the second method of bracketing is better than the first, provided the observers taking part in the test are well trained, so that the accidental error to be ascribed to the observer may be reduced to a minimum.

In what follows it will be assumed that the range-finders are tested by the second method of bracketing, and under that assumption comparison will be made of the different ways of using the instruments.

The use of the instrument by simple coincidence will not be considered, a use which, by reason of its lack of precision, is admissible only in the case of rapidly moving targets.

Moreover, it will be assumed, by way of the first approximation, that no error is made in adjustment. That being assumed, there are two cases to be considered, according to whether the adjustment is made by the one or the other method of bracketing: the simpler case will be considered first.

FIRST CASE.—*The adjustment made by the second method of bracketing.*

In this case, the observer has turned the adjusting screw till, by the second method of bracketing, he has obtained the range, $D_r$, of the adjusting point exactly.

That adjustment once made, any observer, using the second method of bracketing, will find the exact range $D$.

If he uses the first method of bracketing, he will find, instead of the range $D$, the range $D + \theta$, $\theta$ being the systematic error discussed above and varying, of course, with the observer's acuity of vision and eye fatigue.

---

* Such a scale would be gotten, *approximately*, by inscribing opposite the division $\alpha$, not the range $D$, but the range $(D - \theta)$.

SECOND CASE.—*The adjustment made by the first method of bracketing.*

In this case, the adjustment consists in turning the adjusting screw until the mean, $\frac{D_{1r}+D_{2r}}{2}$, of the ranges read at the two limits of coincidence on the adjusting point gives the range $D_r$ of that point. This adjustment brings the range scale to a position different from that which results from the preceding adjustment.

The calculation incident to the second case, being rather tedious, is presented in an appendix.* Here, only the results will be discussed.

It will be assumed that the adjustment has been accurately made; that is to say, that the mean, $\frac{D_{1r}+D_{2r}}{2}$, corresponds to the range of adjustment $D_r$.

The error committed in the use of the instrument for finding any range whatever, $D$, is expressed by:

$$Z = D_r \lambda_r \frac{x^2 (ax-1)}{1 + 2\lambda_r x - a \lambda_r x^2}$$

$x$ being the ratio $\frac{D}{D_r}$; $\lambda_r$, a parameter varying with the acuity of vision of the observer who made the adjustment†; $a$, a parameter which depends upon the acuity of vision of both the observer who adjusted the instrument and the observer who reads the range ($a$ varies from $\lambda_r$ to $+\infty$).

1. Let it be assumed that the same observer adjusts the instrument and reads the ranges.

In this case, $a = 1$

There is no error for $x = 0$ and $x = 1$

If the range of adjustment, $D_r$, is greater than the range read, the systematic error is always less than $\frac{4}{27}\,\theta_r$; but if the range to be read is greater than the range of adjustment ($x > 1$) the systematic error may be very large. For one range read, it will be larger accordingly as the range of adjustment is shorter, but it will practically never exceed the error $\theta$.

Therefore, in the case in which the same observer adjusts the instrument and reads the ranges, it is advantageous to select a range of adjustment that approximates the ranges to be read, if the latter are about the same; but if the ranges to be read are very different, it is advantageous to select a range of adjustment that approximates the longest of the ranges to be read.

2. If the adjustment has not been made by the observer who is reading the ranges, or if the observer's acuity of vision has changed between the time of adjustment and the time of reading, the error $Z$, even at medium ranges, may be considerable when the acuity of vision at the reading of ranges is very different from that at the adjustment of the instrument (Fig. 3).

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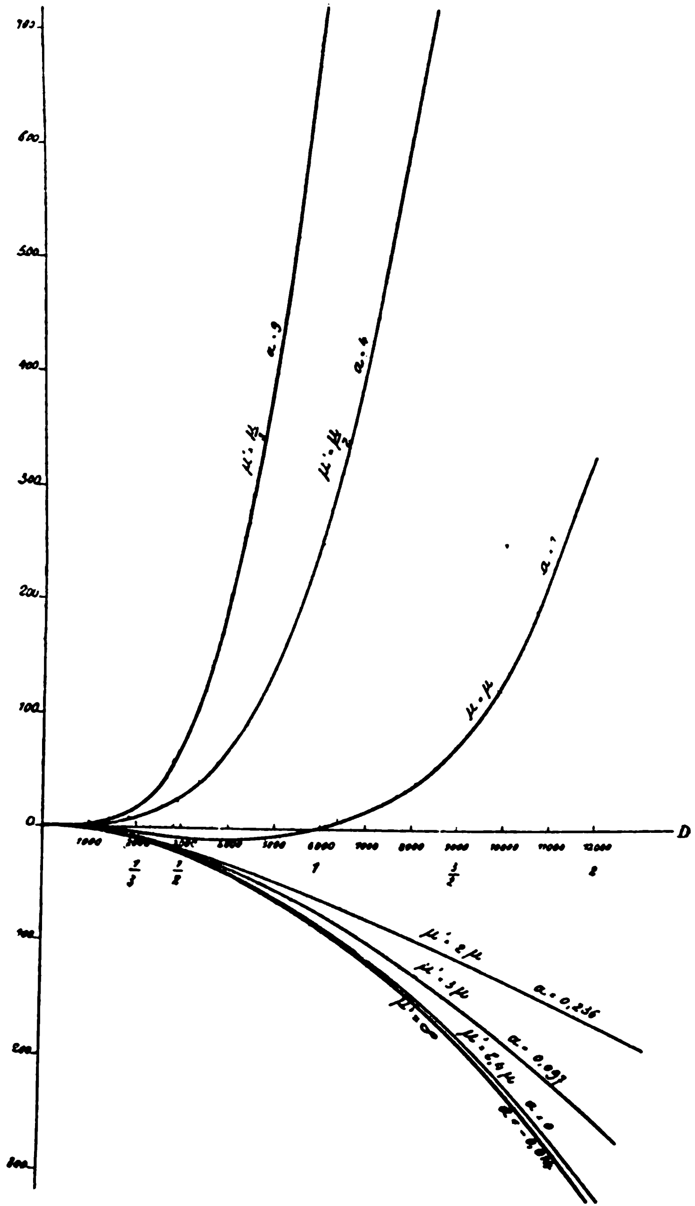
* This appendix will be given in a future number.

† $\lambda_r$ is, for all practical purposes, equal to $\epsilon_r^2$, $\epsilon_r$ being given in Table A for the range $D_r$.



1600

Fig. 3.

Curve of Values of Z

$\mu$ = acuity of vision of the observer who adjusts the instrument.
$\mu'$ = acuity of vision of the observer who reads the ranges.
(1-m. [3.28-ft.] range-finder: $\mu$ = 3000; $D_r$ = 6000.)

3. The adjustment having been made by the first method of bracketing upon the point of adjustment at a range $D_r$, by an observer of acuity of vision $\mu$, if the range $D$ is read by the second method of bracketing, or, what amounts to the same, by an observer of infinite acuity of vision, the systematic error introduced is negative and its value is approximately $D\epsilon\epsilon_r$; it will therefore be greater or less than $\theta$ accordingly as the range of adjustment is greater or less than the range to be read.

## III

## CONCLUSIONS

In résumé, as to the conditions of employment of the coincidence range-finder, the present study leads to the following conclusions:

1. At *short ranges*, the systematic error being negligible, the *first* method of bracketing is the more suitable. The range of adjustment should be about equal to the longest range to be read.
2. At *long ranges*, the systematic error becoming more important than the accidental error attributable to the precision with which, in the second method of bracketing, the scale is brought to the mean position, it is the *second* method that is to be preferred. This statement is strengthened by the fact that the accidental error is partly eliminated in the mean of several readings, while the systematic error remains constant.*
3. Whichever the method used, the reading of ranges must be by the same method as that used in adjustment.
4. A range-finder adjusted by the second method of bracketing may be used for reading ranges by any observer; while, on the other hand, if the first method is used, each observer must make his own adjustment before reading long or even medium ranges; and if he believes that his acuity of vision, as a result of eye fatigue, may have changed appreciably, he must make his adjustment all over again. The first method of bracketing is, therefore, of very limited application.

No mention has been made of the infinity adjustment, or of, what amounts to the same thing, adjustment on the directing mark. It is made by means of an equi-interval graduation on the scale on both sides of the "infinity" mark; and, that graduation representing parallaxes at a suitable scale, the infinity adjustment, or adjustment on the directing mark, is equivalent to an adjustment by the second method of bracketing.

NOTE.—In all the calculations incident to this study, 3000 has been assumed as the average acuity of vision; but authors are not agreed thereupon.

In an article by Major Holbyn in the August, 1907, number of the *Journal of the Royal Artillery*, it is assumed that the average eye can distinguish two points that subtend an angle of two minutes at most; and the corresponding value of $\mu$ would be about 1800.

In the January-February, 1914, number of the JOURNAL OF THE UNITED STATES ARTILLERY, the assumed angle is thirty seconds; and to that would correspond a value of $\mu$ of 7200.

The errors $\epsilon$, $\delta$, $\epsilon_1$, and $\delta_1$, being inversely proportional to the acuity of vision, $\mu$, and the errors $\theta$ and $Z$ inversely proportional to its square, it is very simple, when the errors for a value of $\mu$ equal to 3000 are known, to calculate them for any other value of $\mu$.

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* In short, at all ranges, the first method is more *precise* than the second; but the *accuracy* of the second method is greater than that of the first at long ranges.

In the light of the effect of acuity of vision on the precision and accuracy of readings, is seen the great importance of selecting observers according to that quality of the eye.*—*Revue d'Artillerie.*

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## MR. HAMMOND'S TORPEDO

A year ago an article appeared in *McClure's Magazine* that described the work that had been accomplished by young Mr. John Hays Hammond, Jr., in the direction of creating a radio-controlled torpedo. From this article *The Outlook* quoted at the time of its publication. For several months now Mr. Hammond's invention has been under observation by the coast defense experts of our army, and every sign points to the fact that the tests of his new discovery have been most satisfactory. Mr. Hammond's work is said to be far in advance of anything in the way of radio control that has been developed in Europe, and his experiments have been carried on with such care that the United States is assured of the exclusive use of this new weapon of offense and defense for an indefinite period. What this new weapon means to our army is described in the following statement made by General E. M. Weaver, Chief of Coast Artillery:

"Mr. Hammond has, in the opinion of the Chief of Coast Artillery, at the present time worked out the details of radio control so as to make it possible to apply it in the form of a spar torpedo to a motor boat. His further experiments point to a satisfactory solution of the problem of applying his equipment to a submerged torpedo under radio control from shore. The distance to which this control can be exercised is limited only by the distinctness of vision aided by telescopes.

"It should be pointed out that this new type of weapon does not displace the submarine mine defense. The radio-controlled torpedo is an offensive weapon, and, like the projectiles of guns and mortars, seeks its own target and seeks it under constantly controlled direction.

"If such a means of attack were added to those we now have, we would then be able to attack an enemy's ships by mortar fire falling vertically on the decks of the ships, by gun-fire against the side, turret, and barbette armor, and by submarine mines and radio-controlled torpedo below water. The controllable, mobile type of torpedo has been always considered desirable as a feature of coast-defense armament, but no practical solution of the problem has heretofore been offered."

The *Natalia* has been sent eight miles offshore to a definite goal and then brought back to her dock without any other control upon her helm and motive power than that exercised through the mysterious agency of an electric spark.

Together with the picture of the *Natalia* is published a picture of what Mr. Hammond describes as an electric dog. This little box on wheels, with the two bulging eyes that give it a grotesque resemblance to animal form, follows its "master" around the room, guided and repelled by a ray of light. [See page 142 for illustrations.]—*The Outlook.*

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* In the *Revue d'Artillerie* for July, 1914, in which the original of this article appeared, a continuation was promised; but no subsequent number of the *Revue* has been received. —*Editor of the Journal.*

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*yright by International News Service.* 1602

# BOOK REVIEWS

*Attack and Defense of Fortified Harbors.* By Captain A. P. S. Hyde, C. A. C. 6″ x 9″. 27 pp. 1 il. Paper. 1914.

This is a small pamphlet of twenty-seven pages in which the author has covered most admirably, for its small compass, an extensive subject.

The pamphlet, as stated in the preface, is a compilation of a series of articles written by the author at the request of Colonel William E. McClure, commanding the Coast Artillery Reserve Corps of the State of Washington, and published in the Seattle *Daily Times* in January and February, 1914. The pamphlet is published as Bulletin No. 3, Headquarters Coast Artillery Reserve Corps, dated Seattle, Washington, November 11, 1914.

The first chapter deals with the general principles of coast defense. The necessity for permanent works and the general policy of the United States as to coast fortification are set forth. A list of the fortified harbors in the United States is given. The general forms of attack to which coast fortifications are subject, are given, and, from a consideration of these, is deduced the general principles governing the selection of the most suitable sites for coast fortifications.

Succeeding chapters discuss the subjects of naval attack; the defense against naval attack, including the organization of the defenses, the submarine and aerial defenses and the function of the navy in supplementing the shore defenses; the combined land and naval attack; and the defense against a combined attack. At the end of the book is given a synopsis of a correspondence course in the subject of "Attack and Defense of Fortified Harbors." This course consists of a series of questions covering the subject-matter of the text.

A bibliography also is given, so that anyone desiring to make a more extended study has at hand a list of excellent reference books and papers treating of the subject.

Giving, as it does, the general principles of attack and defense of coast fortifications in concrete form, the pamphlet is of great value to the coast artillery reserves or to any person desiring information on the coast artillery branch of our national defense, and who has not the time to give to an extended course of reading.

✦ ✦ ✦

*Manual of Military Training.* By Captain James A. Moss, U. S. Infantry. Menasha, Wisconsin: Geo. Banta Publishing Company. Sales Agent: Journal U. S. Artillery. 5¼″ x 7½″. 748 pp. Numerous illustrations. Cloth. 1914. Price, $1.90, postpaid.

Captain Moss is determined to reduce the volume of the officer's professional library. Having, in *Army Orders*, reduced 2000 cubic inches to 50, he now, in *Manual of Military Training*, condenses a dozen volumes in one.

The manual is one of infantry training, and in the prefatory remarks it is claimed that the volume "contains everything pertaining to the training and instruction of company officers, noncommissioned officers and privates, and [that] the officer who masters its contents and who renders his company proficient in the subjects embodied [in it], will be in every way qualified, without the assistance of a single other book, to command with credit and satisfaction, in peace and in war, a company that will be an efficient fighting unit."

In the publisher's announcement of the book, its purpose is said to be: "First, for use in connection with the instruction and training of cadets in our military schools; second, for the instruction and training of company officers of the organized militia; third, as a handy guide and reference for company officers of the regular army."

The work comprises three parts.

Part I, "Drills, Exercises, Guard Duty, Target Practice, Ceremonies and Inspections," contains six chapters and presents, it appears, the entire infantry drill regulations, manual of interior guard duty, and manual of the bayonet, and extracts from the manual of physical training, signal book, and small arms firing manual.

Part II, "Miscellaneous Subjects Pertaining to Company Training and Instruction," contains fifteen chapters, the subjects of which may be briefly indicated as follows: administration; discipline; instruction; minor tactics; map problems; information; security; map reading; sketching; wagons; marches; first aid; courtesy; deportment; and the rifle.

Part III, "Company Field Training," contains twenty chapters, and treats at some length of the company in attack, in defense, on outpost, and in scouting and patrolling, of night operations, field orders of enlisted men, intrenchments, obstacles, field firing, camping, and individual cooking.

The volume is a handy one for company officers of coast artillery as well as for those of infantry.

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*Pages d' Histoire, 1914.* Paris: Librairie Militaire Berger-Levrault, 5 Rue des Beaux-Arts. 4½" x 6¾". Paper. Price, 60 centimes.

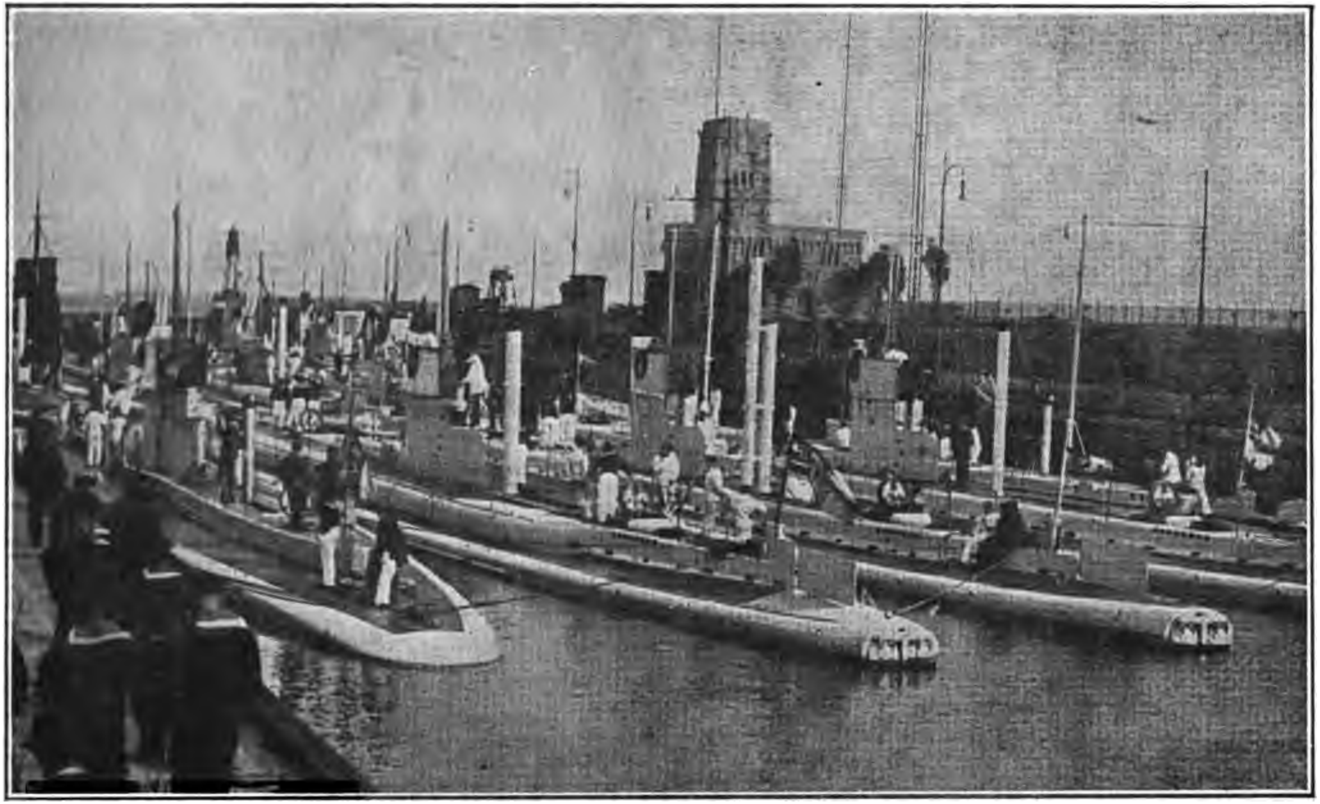
The Librairie Militaire Berger-Levrault is issuing a series of war pamphlets under the title *Pages d'Histoire, 1914*, of which several numbers have been received.

The object of the series, the publishers state in their foreword to the first number, *Le Guet-Apens*, is to collect official documents and important articles appearing in the press.

The first number is concerned with the happenings of July 23rd, 24th, and 25th, and comprises three sections: (1) *Le choix du moment*, in which are presented extracts from *Dernières Nouvelles de Berlin*, *Tægliche Rundschau*, *Tribuna* (of Rome), and *Berliner Tageblatt;* (2) *L'ultimatum Autrichien*, which is the official document; and (3) *L'émotion en Europe*, in which are presented extracts from the French *Journal* and from many German, Russian, Roumanian, English, Italian, and other French publications.

The second number is *La Tension Diplomatique;* the third, *En Mobilisation;* the fourth, *La Journée du 4 Aout;* the fifth, *En Guerre;* the sixth, seventh, and eighth, *Les Communiqués Officiels;* and the ninth, *Extraits du Bulletin des Armées de la République*.

*Frontispiece.*



*Photograph by Boston Photo News Co.* 1603

GERMAN SUBMARINES IN WILHELMSHAVEN

JOURNAL
OF THE
UNITED STATES ARTILLERY

VOL. 43 No. 2 MARCH-APRIL, 1915 WHOLE No. 132

### First Prize, Essay Competition of 1914

# COAST ARTILLERY TARGET PRACTICE: ITS PURPOSE AND HOW BEST TO ACCOMPLISH IT

BY MAJOR EDWIN LANDON, COAST ARTILLERY CORPS

The writer had prepared an article on this subject and was about to submit it, when the November-December, 1914, number of the JOURNAL was received. The article appearing in that number on *The Development of Coast Artillery Gunnery in the United States During Twenty Years*, by Major J. M. Williams, Coast Artillery Corps, contained so much of what had been prepared, and was so excellently put, that what appears below has been rewritten with the idea of avoiding useless repetition. The writer's review of the last twenty years development was conducted from a somewhat different point of view, but Major Williams' article gives sufficient data to make clear the points it was intended to bring out.

It is impossible to read over the old orders affecting our practice without being impressed with the very great progress that has been made, and with the earnest and sincere desire of the authors to contribute to positive advance each year. But the annual orders, as they have come to be, require a very great effort to master. For some years it has been required that officers be assembled to demonstrate their mastery of the instruction order by recitation for a number of days after receiving the order. The writer's experience is that the time prescribed is all required in order to ensure the harmonious interpretation of all the many regulations affecting practice.

The arrangement of the different subjects has been changed many times, and recently the order has included a statement of the purpose of the practice, although this appears toward the end under the heading "Miscellaneous." However, it is not intended to pick flaws, but only to seek to stimulate interest, in the change of method which is here advocated for getting out this annual order and for executing its provisions. The writer has had much recent experience, both as an irresponsible observer and as an umpire of practice, as well as as a responsible conductor, and has observed a great deal of confusion in thought and purpose, which, it is believed, can be almost wholly corrected by the simple device of adopting the form prescribed for tactical orders in presenting the regulations affecting practice.

The words chosen by the JOURNAL for the title of this article reflect the influence of the form for reasoning known as "The Estimate of the Situation"; they call for a statement of the "object in view," or "mission," "purpose," and for a "decision." This form for reasoning was developed in order to cultivate a systematic, rapid, and reasonably certain means for any trained officer to arrive at correct conclusions and decisions in harmony with orders thought out by the same formal processes by his immediate superior, and thus to relieve the superior of present concern as to methods to be adopted by the subordinate, except in so far as the prescribing of methods is necessary in order to secure cooperation with neighboring commands and the supply services. *The superior's chief concerns for the trained and competent subordinate are that he has a task clearly stated and that he is given the means for accomplishing that task.* Where this "rational" system of control has been most highly developed, the resulting reduction in length and number of orders required to accomplish a given task is most marked; and, what is far more important to the maintenance of efficiency, the subordinate's brains are fully employed and exercised in a way to keep him far more alert, mentally active, and resourceful than is possible under the "jural" system of one fountain head for all important thought and decision. The "rational" system develops the idea of loyalty to the announced plans of the chief, rather than to the chief in person; it makes more prominent the idea which has always obtained, that loyalty is another name for partnership, and therefore a mutual obligation; it carefully distinguishes the sphere of responsibility of each commander and grants without reserve the authority to fully meet that responsibility in training, with the object of developing ability to estimate and decide correctly and harmoniously on the part of each commander, both superior and subordinate. In no wise does this "rational" system minimize the responsibilities of the superior—it simplifies the performance of his duties in times of action; it does not excuse him from acquaintance with the best methods of performance for the tasks he sets—it imposes upon him the duty of sufficient acquaintance with the methods likely to be adopted to enable him to select for the performance of a particular task a subordinate in whose estimates and decisions he has confidence; it does not abolish regulations—it provides in advance for the most unexpected exceptions; and it does all this and more, through a system of training.

Those readers who are interested in following the trend of current thought upon questions of morals and conduct, will recognize the sources from which the terms "rational" and "jural," as here used, are borrowed. They appear to the writer to include in single words more of the distinction which it is sought to describe than the terms "decentralization" and "centralization," "independent" and "subordinate," and the like.

The "rational" system of training is probably most highly developed in the armies of France and Germany. It is progressive from recruit training to the Grand Manuevers. It is characterized, at least so far as officers are concerned, by the requirement that each grade perform its part in the training successively and under the close personal supervision of superiors of all grades. Each exercise is followed by a critique. One is permitted to make mistakes to see if one can profit by them; and, through experience and criticism on the spot, it is insured that the mistakes are observed. The same system is followed in target practice, which is largely field firing, as distinguished from range firing. This training is supplemented, especially for artillery officers, by attendance at schools of fire, where each is instructed and tested, every other day for months, in the solution of problems in the field involving the actual expenditure of ammunition. Solutions are criticized as soon as the necessary data can be collected and posted, usually the next day. The officers' training is further supplemented by the war game, which is attended by superiors very much as recruit instruction is attended. As a result, the methods employed by subordinates are not only corrected by criticism on the spot, but they are intimately known to their superiors; and so the need of prescribing them on any occasion of action is minimized. A further valuable result is very much liberalized regulations, as compared with those in force when the "jural" system prevailed. The "rational" system frankly and continuously recognizes that no set of rules or regulations can provide for all situations; its whip is criticism on the spot. This criticism has for its primary objects instruction and coordination; the solution criticised is stated to be satisfactory or unsatisfactory. The reputation made at critiques to a large extent determines the suitability of the officer criticized for promotion or for continuance in service.

Of course, there are many obvious objections and some insuperable difficulties to the application of the details described above to the American coast artillery service. We have already begun to adopt some of the devices used, such as the analysis of practice by a board, the war game, the requirement that battery commanders fire at practice when ordered, instead of at their own pleasure as formerly, and many others. However, we still hang on to many things inconsistent with the "rational" system. The writer believes that these will slip off easily and scarcely observed, just as soon as we consciously endeavor to adopt this "rational" system. In the coast artillery war game recently introduced, we have a splendid means of extending the "rational" system.

All our army traditions are closely associated with the "jural" system. It is thought quite natural that the coast artillery should be slow in making the change, because its positions are fixed and of comparatively small extent; it is limited to the defensive; and the cost of its material is so great, compared with that used by other arms, that the advantages of delegating authority to decide its questions of either technical, administrative, or executive nature, has not appealed to its upper ranks to the extent forced upon the other branches by modern military conditions. Our navy, which was the last branch of the service, next to our own, to study and apply the "rational" system, has already gone far in the extent of the application. It is believed that the coast artillery will gather speed very quickly in applying this system. Our organization as a corps under supervision of a special division of the General Staff, the recent creation of district commands, our actual presence in the positions we expect to occupy in active service, our possession of a school attended by each of our officers, the very great influence of local conditions on effective training and action, all favor a quick adoption of the system.

Regulations for the Instruction and Target Practice of Coast Artillery Troops, when they are adapted in form as they are now becoming adapted in spirit, to the "rational" system, will be greatly simplified and abbreviated. The stimulus to thoroughness and the opportunity which can be obtained so well in no other way for estimating individual ability, will be invaluable. There is more than one perfectly good and satisfactory way for performing such simple operations as addition or subtraction, or working an adding machine. The need of uniformity in these matters is met when results agree. It is generally admitted in schools nowadays that the instructor who permits the fullest play to individuality in the student will eventually obtain the most reliable results, because he uses experience and reason instead of rule and precept wherever possible. In the cases of such exceedingly complex operations as hitting targets with heavy ordnance, or planting, maintaining, and operating mine fields, it is confidently believed these arts will be more highly developed and the more skilful performers will be more certainly discovered through the "rational" than through the "jural" system of control. To be efficient, a highly educated army officer should have confidence in, and consciously act upon, his own estimates and decisions. In peace, one of the supreme tests of efficiency is performance at target practice, on which occasion the fullest possible freedom of action should not only be allowed, but positively provided for.

Uniformity, when practically attainable, is a very desirable, and often necessary, condition for military efficiency. The principal military reasons for uniformity are ease and simplification of supply; *i.e.*, supply of material necessarily manufactured by others than the troops, and supply of instructed men to replace casualties. Uniformity is obtained by the enforcement of regulations and customs. But to be effective, these regulations must be broad enough to include all cases not specifically excepted. If they descend into detail or assume conditions not positively known to exist, they do not accomplish uniformity, and therefore are inappropriate, inadequate, useless, or detrimental, as the case may be. Regulations are conservative in nature: they seek to prevent, to restrict, to rigidly mold. Knowledge and experience make most regulations of a technical nature unnecessary.

All drill regulations have been liberalized very greatly in recent years, and large parts of the so-called drill regulations now in force are not regulations at all, but dissertations of a most general nature, useful, valuable, but shorn of their former mandatory character. This has happened in conscious or unconscious response to the steadily growing change from the "jural" to the "rational" system of control; to the growing conviction that any position requiring an educated man to fill cannot be economically and efficiently occupied, unless that man's experience and powers of reasoning are utilized to the full. One cannot act rationally, unless one is supplied with a purpose; nor efficiently, unless one's experience fits one for the accomplishment of the purpose. In this matter of purpose, all will agree there should be uniformity.

There is need of a formal estimate of the situation in the case of an administrative order just as much as in the case of a tactical order. The forms for estimating the situation and for tactical orders are the results of the conscious adoption of the "rational" system. Practically, but to a very large extent unconsciously, we are in the process of change. When the change can be completed consciously and with conviction, it is believed that most of the inconsistencies in regulations and orders affecting practice now existent will automatically disappear, and decisions on fine points will not be heard of.

Herewith is given a rough outline of a possible estimate of the situation and a draft for an annual War Department instruction order in so far as target practice is concerned, following lines advocated. It should be clearly understood that this particular solution is not advocated as the best, nor as complete. The writer is not in possession of sufficient facts upon which to base a satisfactory solution. It is offered by way of illustration only.

## Coast Artillery Target Practice

### AN ESTIMATE OF THE SITUATION FROM THE POINT OF VIEW OF THE WAR DEPARTMENT

Object:

In preparation for war, to develop and test proficiency in gunnery and submarine mining under service conditions, including exercise of tactical command.

CONSIDERATIONS WHICH HAMPER:

(a) Small size of appropriations and great cost of ammunition.

(b) Distribution of troops: no fort fully manned; practice prohibited at some forts by considerations of safety.

(c) Some forts not equipped as per project.

(d) Small number and low power of available towing boats, and unseaworthiness of some, making it necessary to give great consideration to season and weather. Small number of mine planters.

(e) Unequal deterioration of powder at different points, and other reasons making it necessary to consume much time in inventories to insure, by transfer of powder, the economical expenditure of available appropriations.

(f) Great distances between forts, making it expensive and difficult to provide for personal supervision and assistance by department and district commanders.

(g) Impracticability in the past of keeping those officers not at the Coast Artillery School, on permanent boards, or in the War Department, promptly informed as to the latest additions to technical knowledge.

(h) The generally wide separation of quarters for coast artillery personnel from the matériel assigned to it, and the difficulty (principally financial) of establishing camps or quarters near enough to batteries to include regular watches as part of practice.

(i) The necessity of constantly using coast artillery officers and men in ordinary post administration, guarding prisoners, etc.

(k) The impracticability in the past of establishing anything like a school of fire for officers, except as an incident of their course at the Coast Artillery School, which experience practically all officers go through but once.

(l) The practical difficulty in the past of making drill regulation changes in time for prompt trial at practice without including them in the Instruction Order, thus complicating this order with detail.

(m) Insufficient number of enlisted specialists.

(n) No unassigned enlisted men available for permanently necessary details away from companies and batteries.

(o) Rather undeveloped ideas on tactics as applied practically to the use of the material actually on hand.

(p) Manning less important batteries, in order to keep up supply of local instructors for "coast artillery militia."

(q) No organized service of information, except the purely paper one of the Naval Patrol Service; and only the very limited experience of Joint Naval and Coast Defense Exercises and occasional "War Condition Periods" to develop systematic methods of holding the personnel ready for action without undue fatigue.

(r) No experience with aeroplanes in coast defense problems.

RESOURCES:

(a) A specific appropriation for target practice with balances indefinitely available.

(b) Sufficient ammunition (reserve) already distributed to permit practice at most convenient time in any given locality.

(c) Coast artillery district commanders unhampered by administrative detail that is not directly connected with the instruction of the troops and the efficient maintenance of the armament.

(d) Coast defense commanders with ample powers, and with personal experience as battery commanders with modern armament.

(e) Fort and fire commanders with similar personal experience.

(f) Sufficient specially trained graduates of the Coast Artillery School to fill all technical staff details.

(g) Battery commanders practically all graduates of the school.

(h) Young, well educated, and carefully selected lieutenants.

(i) Superior trained men for technical noncommissioned staff duties.

(j) Companies filled twice annually to full authorized strength.

(k) Flexible size and organization of companies permitted by law.

(l) Fairly well established knowledge of reasonable expectations with respect to performance of matériel and personnel in battery practice.

(m) Improved organization for instruction of coast artillery militia by detail of inspector-instructors and specially selected noncommissioned officers, which, together with advance in knowledge existing in the coast artillery militia itself, makes the retention of regular companies at unimportant assignments less necessary or desirable than formerly.

Discussion:

1. *Organizations to fire.*—Drill regulations define fire command and battle command practice as well as battery practice. We have been having mine practice. "Mine command" practice, a combination of battery or fire command practice with mine practice, has been proposed, but never authorized. So far as the War Department is concerned the more of all kinds of practice obtainable with available funds, the better. A minimum standard of excellence in the more elementary forms should be assured before progression is permitted to the next. There is no good reason for holding back those who are ready to progress in order that all may progress together. The "rational" system not only permits but requires progress by those who are ready for it. This is its form of competition.

2. *Kinds of practice.*—What is wanted in any coast defense is battery, fire, mine, and battle commands prepared to do their best under service conditions with the facilities actually available, or which may reasonably be expected to be available at the outbreak of war. Green troops may require a small amount of firing under less severe conditions as to rapidity of loading and firing, than obtain under service conditions; but with regular troops and the present enlistment period, few organizations are so depleted of men having previous experience as to make this a matter of general importance. Green officers should not be expected to suddenly perform their duties under service conditions without previous experience under simpler conditions. These are they who should first attend schools of fire, when schools can be organized. To give such officers needed elementary experience in the conduct of fire at the cost of service practice experience for expensively maintained regular organizations, is not economical. The Coast Artillery School as at present conducted does not provide sufficient facilities to insure the desirable and necessary experience in gunnery for battery and higher commanders. The school's facilities might well be supplemented by schools of fire at other places. It is thought no regular organization should be intrusted for instruction and practice to an officer who has not had a certain minimum

experience in gunnery, as distinguished from practice, and who has not had a minimum experience in conducting battery practice under a skilled instructor not restricted by the usual rules. Whether the time has arrived when these ideas can be enforced can only be known in the War Department. Assuming that all commanders have had the experience prescribed, the maximum requirement for a battery practice would be the successful placing of the center of impact on the target, or, at least, one hit on the target. To continue firing at the same target after securing this much serves no purpose, except to test endurance, which present appropriations are scarcely large enough to stand. This consideration would indicate that the least allowance for a single battery practice should be a sufficient number of rounds to give an even chance under average conditions of securing one hit, but the allowance should be flexible and subject to instant change at the time the practice is being held. Any ammunition remaining after the battery practices should be devoted to fire and battle command practice and to the needs of such schools of fire as may be established.

Just when a battery has fired enough to "pass," or to have had a reasonable chance of "passing," should be determined by one in authority at the time the practice is held—preferably the district commander, in our organization.

To meet these conditions it will be necessary to adopt an ammunition allowance expressed in money, instead of in rounds, and, within the money allowance, to make all ammunition actually on hand available for practice. If the general principles here advocated are admitted, the functions of the War Department largely cease when they have been announced, and the functions of the district commanders begin. Among the advantages of the system, is a great stimulation to activity at district headquarters, for the district's responsibilities are substantially increased and each district enters a very real competition for results. To complete the application of the "rational" system, the district commanders should assemble annually for a personal report and discussion (critique) of results obtained and methods used.

3. *Established requirements.*—Regulations as to "powder blending," "powder serving trays," "compound blending," "care in seating projectiles," should properly appear in drill regulations, not in the practice order.

4. *Duties of commanders.*—Duties of coast defense,

battle, fire, and mine commanders, as prescribed in current instruction orders, depending on their nature, belong in drill regulations or in the practice orders of their respective immediate superiors.

5. *Umpires.*—Umpires have no place in the "rational" system. Such of the duties now assigned them as remain necessary to be performed belong to the district or other commander, in person, or to his staff.

6. *Minutiæ.*—Suspension of other military exercises for a stated period before practice, regulations about attendance, number of guns to be manned, arrangement of projectiles, etc., etc., disappear automatically from the War Department orders with the adoption of the "rational" system.

7. *Trial shots.*—Are trial shots a service condition? If they are, then orders about them belong in the drill regulations along with those concerning the manipulation of the plotting board, range board, and other devices for obtaining proper data. If they are not a service condition, their utility or desirability in any given case should be a matter turned over for decision to the officer who finally decides on the share of the money allowance assigned to the battery believed to need them. The proposition to use trial shots should originate with the battery commander.

8. * * * * * * *

9. *Targets.*—Kind of targets to be used is a matter for decision by the officer who allots the funds made available for any given practice or locality, they being paid for from the appropriation for target practice. Whether or not the Ordnance Department makes the targets is an administrative detail.

10. *Course of target.*—This should be decided by the commander who sets the problem, supervises the test, and conducts the critique. He should be given every latitude, if the "rational" system is adopted. He himself is subject to criticism in his turn.

11. *Observations for record.*—Probably the only details the War Department need prescribe, are such as to insure a reasonable record of the performance of the different lots of powder used. This would include the usual record of measurements of projectile and charge, of the powder pressure, of the point of fall referred to the point aimed at, of the meteorological conditions, and of the azimuth and range of the point aimed at. These records should not be insisted upon by the

War Department to the detriment of the practice as a service test.

12. *Figure of merit.*—As Major Williams points out in his article, so far as gunnery is concerned, the most satisfactory standard of comparison is the mean absolute deviation from the target. The rest of the figure of merit disappears in the "rational" system. Its place is taken by the critique and the reputation made thereat.

13. *Mine practice.*—Mine practice should also have a money allowance apportioned to districts and allotted by district commanders. It should have a minimum standard of excellence, which, when attained, should qualify for participation in practice that will develop and test the mine command organization as a whole. The mine commander should be confronted with the problem of operating loaded mines and using his batteries at the same or different targets all at the same time. We have told Congress we can do this. We ought to try it.

14. *Aviation.*—So far as known to the writer, there has been no active cooperation between the Aviation Corps and the Coast Artillery in target practice. Current events indicate a very great field for such cooperation, which ought to be investigated practically.

15. *Service of security.*—The cooperation of the Navy in giving information of an enemy's approach has never been practically tried, so far as known. There is a paper organization for the purpose. This has practical bearing on target practice under service conditions because we are now in the dark as to how much such cooperation can be relied on to secure proper rest for a coast artillery garrison strong enough to furnish only one manning party. It has been suggested that idle Army transports be used to transport the district commander, his staff, and sufficient target material, together with the personnel for handling this material and for making records, from harbor to harbor. This scheme would serve the purposes of easy maintenance of a trained organization for this work, of furnishing a vessel having sufficient power and seaworthiness to tow targets at good speeds in most weathers, and of introducing the element of uncertainty as to the exact time of appearance, which is bound to have great practical effect on the performance of the personnel.

DECISION:

To issue the following order:

General Orders,
No. ..

War Department,
Washington, March...., 191..

1. Regulations for the Target Practice of Coast Artillery Troops, 191..., are rescinded.

2. The War Department apportions the funds available for coast artillery target practice, for mine practice, and for courses at such coast artillery schools of fire as may be organized in any coast artillery district or separate coast defense command, including funds for hire of necessary water transportation.

3. The War Department will act upon applications for the cooperation of the Aviation Corps in coast artillery practice.

4. The War Department will arrange, when practicable, for the cooperation of Naval Districts and of individual naval officers in target practice, upon the receipt of applications.

5. Department commanders will arrange for the cooperation of coast artillery militia organizations and individuals, when practicable, upon receipt of applications.

6. Coast artillery target practice will be ordered and conducted to develop and test proficiency in gunnery and submarine mining under service conditions, including the exercise of tactical command.

7. Department commanders will exercise general supervision.

8. Coast artillery district commanders and coast defense commanders unattached to districts will assign organizations to calibers and batteries, set times for practice, be present at practice, finally decide upon all the conditions of practice, and conduct or personally supervise critiques as soon as the necessary data can be collected after practice. They will prepare themselves to attend a critique of the year's work to be held in Washington in December, 191....

9. Both day and night practice are required, wherever practicable.

10. Whenever practicable on occasions of practice, organizations will man matériel permanently assigned them.

11. Coast artillery district commanders and coast defense commanders not attached to districts will report by name officers needing gunnery experience before being intrusted with the conduct of practice under service conditions. If the number of such officers and the state of the apportionment

justifies, they will submit programs for the organization and conduct of schools of fire at selected posts in their commands.

12. Requisitions for coast artillery target practice ammunition may be filled by coast defense ordnance officers from reserve on hand, on the order of coast artillery district commanders or unattached coast defense commanders, when time does not permit action in the usual way before the date set for practice. Similarly, target material and other supplies for practice may be procured by local purchase to be charged to the district or coast defense apportionment by the proper disbursing officer. Requisitions for submarine mine matériel needed for practice may be similarly filled, or material ordered purchased locally, within the limits of district or coast defense apportionment. Necessary water transportation may be hired on order of the district commander under similar restriction.

13. So far as possible, without interfering with the conduct of the practice as a service test, data called for by accompanying forms will be reported to The Adjutant General of the Army. District commanders will furnish copies of their instructions affecting the conduct of practice through their department commander.

By order, etc.

Upon receipt of such an order the district commander should estimate the situation and come to a decision. Great care would have to be exercised not to drift back into "jural" methods, but to leave all possible latitude to coast defense commanders and to require them to give latitude to their subordinates for gaining knowledge through personal experience, after estimating and deciding. In starting the system it might be appropriate to require formal written estimates and decisions from each commander. There can be no doubt that, in service, coast defense commanders will find themselves confronted with many grave technical questions, which they alone will have to decide. They should be given the opportunity to practice such decision. Every decision made for them in peace hampers and weakens their power of decision.

No attempt is here made to go into the details of the district commander's estimate. It must be apparent that it is a difficult one. But this difficulty is almost entirely due to the fact that it has never been tried. All of the decisions reached probably could not be announced in one general order for the district. Without going into lengthy detail, all can appreciate that local problems could and would receive a fuller consideration under this system than under the present system. One of the first things to do would be to obtain the several coast defense commanders' estimates of the situation involving decision as to the most effective organization of their coast defense commands for war, especially decision as to which batteries and accessories should be manned for war by the available regular troops. After criticism by the district and department commanders, these decisions should be approved for trial at the next target practice. It would be quite legitimate and in accord with the "rational" system to accept the coast defense commanders' decisions without criticism, until after test in target practice. The district commander can readily arrange ammunition allowances, target courses, etc., to create special situations for practice which will do much to test the correctness of the decisions made, reserving criticism until after practice. One great advance possible under the proposed system is the leaving of coast defense commands in the dark as to their ammunition allowance. They can be required to prepare all ammunition on hand for use, thus ensuring powder blendings at least once a year, so long as these are considered necessary, and incidentally forcing the provision of an equipment for powder blending adequate to meet service conditions. The district commander can stop ammunition expenditure at any battery by the simple order to "cease firing," which can be given on information, by signal, from the target-towing vessel as to the results being obtained.

One early development anticipated from the application of this system is the equipment of motor driven targets for fire and battle command practice, and especially for mine and mine command practice. The modern out-board motor for light craft is an exceedingly cheap affair—less than $100.00 apiece. With a permanent target handling detail for the district, transported from place to place on a small transport, it would be very easy to develop much skill in handling such targets. It would be very simple to keep track of results of firing by a plot made on the transport with the aid of self-contained horizontal base range-finders, for locating targets, and sextants, for locating the ship with respect to points on shore. To start with, the rate of fire could readily be reduced in order to avoid confusion. The point is to present a real service problem, and to determine at the time of the firing just when sufficient ammunition has been expended to give results which will be valuable for a critique.

By placing all target handling details and questions under the direct management of district headquarters, the elements of surprise and uncertainty so unsatisfactorily handled now, would be as effectively introduced as it is possible to have them in peace.

It is hoped that the reader believes with the writer that, by virtue of the district commander's place in the organization and the intimate knowledge and appreciation this must give him of local conditions and the capabilities of his officers, he is well qualified to get up and carry through some very interesting and instructive work that is bound to put every one of us on his mettle in a way the old order can never do. The old form of order has carried us far, and the writer believes it perhaps has done more for us than the system here advocated would have done in the same time, but it is firmly believed that the time can never be so ripe as the present for the change here advocated. We belong to a highly technical profession. It has been built up through the last twenty years with great effort. We have the districts established. They are the natural means for adapting ourselves to the "rational" system in current use in the most highly developed military organizations everywhere, and in civilian professional and business life the world over. We are now twenty-one.

# GUNS, AMMUNITION, AND ACCESSORIES*

By Major EDWARD P. O'HERN, Ordnance Department

## Armament

### PANAMA CANAL

During the past year there has been completed and issued a large amount of seacoast armament destined for the defenses of the Panama Canal and the insular possessions. That forwarded to the Panama Canal defenses includes nearly all the armament destined therefor. All the funds needed to complete the manufacture of the guns and carriages for the contemplated armament have been appropriated.

### *16-inch Gun and Carriage*

The 16-inch gun that was formerly stored at Sandy Hook is, as is commonly known, destined to be mounted in the defenses of the Panama Canal. A disappearing carriage of the general type of the 12-inch, Model of 1901, is being constructed for it at the Watertown Arsenal. The work is so well advanced that the carriage is expected to be ready for shop test next April.

The following is a brief statement of the ballistics of the 16-inch gun, with which data many of you are doubtless already familiar:

| | |
|---|---|
| Weight of projectile | 2400 lbs. |
| Weight of charge | 660 lbs. |
| Muzzle velocity | 2250 f.s. |
| Maximum range (15 deg. elevation) | 18600 yds. |

On account of the considerable height of site on which the gun is to be mounted, the maximum range will be further increased.

Computed penetration in K. C. armor:

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* Extracts from a lecture delivered before the student officers of the Coast Artillery School at Fort Monroe, Virginia, November 20, 1914.

| | |
|---|---|
| Normal impact, | |
| at muzzle | 24 inches |
| at 5000 yards | 20.6 " |
| at 10,000 yards | 16.8 " |
| Impact 30 deg. from normal, | |
| at muzzle | 22.9 inches |
| at 5000 yards | 18.4 " |
| at 10,000 yards | 15.5 " |

### *Mortars*

The illustration (Fig. 1) herewith shows a 12-inch mortar and carriage of the types being installed in the Panama Canal fortifications.

These mortars are much more powerful than any thus far mounted in the fortifications of the continental United States. They have a muzzle velocity of 1800 f.s. in the outer zone, and a maximum range of 19,000 yards. These are an increase of 300 f.s. in the muzzle velocity, and of 4000 yards in the maximum range, as compared with the earlier mortars. They are of the wire-wrapped type of construction, and have a very large factor of safety in their elastic tangential strength as compared with the expected powder pressures. Similar mortars are now under construction for the San Pedro Harbor, California, defenses.

It seems probable that some of the more powerful type will be eventually manufactured to replace or to supplement those of the earlier types in some of the more important of the older batteries.

### *Panama Howitzers*

There are under construction for the defense of the Panama Canal locks a number of 4.7-inch howitzers, together with an extra supply of pedestal mounts, so that the howitzers can all be quickly concentrated for the defense of threatened locks at either end of the canal. These howitzers fire a 60-lb. shrapnel, or high explosive shell, as do the field artillery howitzers, but are more powerful in that they have a maximum muzzle velocity of 1300 instead of 900 f.s. They have an extreme range of 10,000 yards, a range not likely to be exceeded by that of any weapon apt to be brought against them.

Their ammunition is semi-fixed, the projectile and cartridge case being carried separately, but capable of being readily assembled immediately before loading the howitzer.

The powder charges are made up in three sections so as to readily provide for firing in any one of three zones, thus securing greater angles of fall when needed.

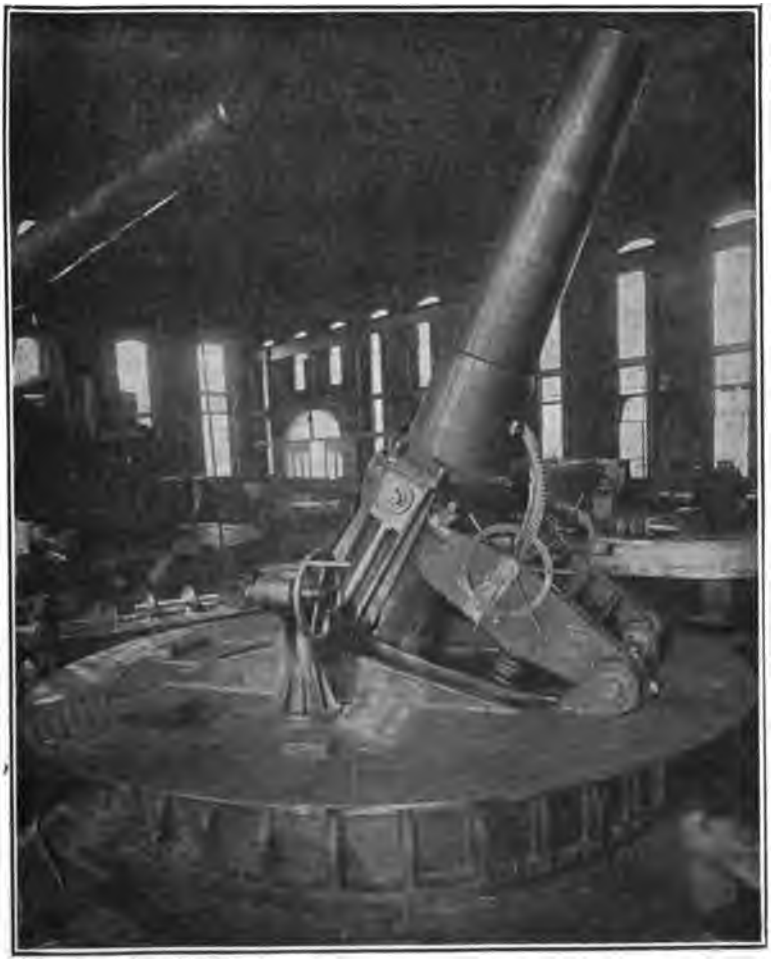


FIG. 1. 1301

12-inch mortar, model 1912, mounted on carriage, model 1896 MIII.

The elevation scale and fuse-setter are, however, graduated from zero up to the limit of the range for each velocity, so that the highest velocity can be used for all ranges when great angles of fall are not required.

The howitzers and mounts are expected to be completed shortly. An ammunition allowance has been established, somewhat less than that for the corresponding mobile type. As they are to be used only on the defensive, a smaller allowance seems justified.

Some of this ammunition is now under manufacture and it is hoped that the next appropriation will be sufficient to justify the ordering of all or nearly all the remainder of the supply.

### INSULAR POSSESSIONS

Congress at its last session appropriated all the funds needed to complete nearly all the armament contemplated for the Philippine Islands and Hawaii. Practically all the Hawaiian armament and the greater part of the Philippine armament has been forwarded and mounted.

There have been furnished for land defense purposes in Hawaii, in addition to a supply of mobile artillery, certain seacoast guns and mortars taken from those seacoast fortifications in the continental United States where they could best be spared.

### CONTINENTAL UNITED STATES

The last Fortification Act appropriated sufficient funds to cover the estimated cost of completing the contemplated armament for the defense of San Pedro Harbor, California.

Of the other approved but uncompleted projects the most important is that for the proposed armament of Cape Henry. Congress has already appropriated funds for procuring a site for these fortifications, and the work of securing the property by purchase or condemnation is understood to be in progress.

Under the plans thus far prepared, it is proposed to mount the 14-inch or 16-inch guns in single-gun batteries with wide intervals, and to emplace the mortars in batteries of four mortars each, placed sufficiently far apart for each to cover what would otherwise be a dead space close to the other.

The question of turrets for the large caliber guns will be discussed later.

### MODIFICATIONS OF 3-INCH GUNS (15-PDRS.)

On account of the greater safety in operation secured by means of a breech mechanism in which the firing pin is out of alignment with the primer while the block is being closed, such a mechanism has been developed and satisfactorily tested for application to all 3-inch (15-pdr.) guns, Model of 1902, Bethlehem, in service.

The new mechanism is practically identical with that in use on 3-inch (15-pdr.) guns, model of 1903. It embodies the continuous pull firing mechanism as well as the eccentric block, the combination of these features giving a maximum safety. As the change involves the additon of a new breech bushing, it will be necessary to return the guns to Watervliet Arsenal.

Arrangements are being made to have them forwarded in groups of eight or ten. The mechanisms will be made in advance so that it will not be necessary to keep the guns at the Arsenal for more than a short time.

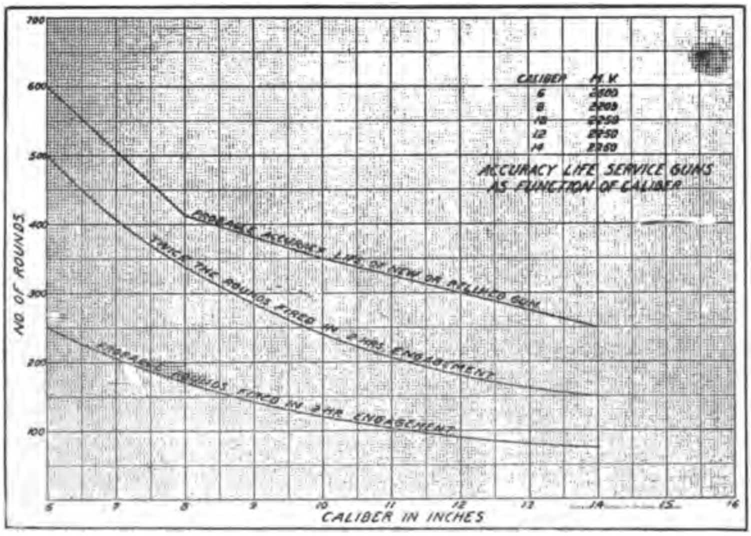


FIG. 2. 1606

An effort is being made to apply a similar type of mechanism to 3-inch (15-pdrs.) model of 1898, and to 4.72-inch and 6-inch Armstrong guns, that is, to all types using fixed ammunition and not now equipped with an eccentric block.

## ACCURACY LIFE OF GUNS

The curves herewith (Fig. 2) indicate a very satisfactory accuracy life for service seacoast guns as compared with the probable number of rounds fired in a two hours' engagement. It shows that guns can be continued in use at target practice until about two-thirds worn out, and still have sufficient remaining accuracy life for an engagement. If the principle be adopted that guns be relined when one-half worn out, it is evident that guns of somewhat greater power can be furnished at a sacrifice in accuracy life. Thus, a 14-inch gun having an accuracy life of 150 rounds would meet this condition. Such a gun would have a chamber capacity of approximately 19,000 cubic inches and would give a muzzle velocity of approximately 2350 feet per second for a 40-caliber gun, and approximately 2500 for a 50-caliber gun, with the standard weight of projectile, 1660 pounds. If the rule be adopted of using reduced charges largely or wholly at target practice, a somewhat larger chambered gun can be furnished without violating the foregoing principle. Thus, it is estimated that a 14-inch gun with a chamber capacity of 19,300 cubic inches would have an accuracy life of approximately 125 rounds with service charges, and this value is apparently too low to justify the habitual use of such guns with full charges in target practice firings.

## AMMUNITION

### ALLOWANCES

Before proceeding to a consideration of the status of the reserve ammunition supply, a brief reference will be made to the basis of the allowances and to the instructions governing the distribution.

The allowances of reserve ammunition for the various calibers of seacoast cannon, as established by the Taft Board for the continental United States, are based on the principle of providing sufficient to carry one-half the guns through a two hours' engagement. They vary from 200 rounds for the 3-inch (15-pdr.) to 40 rounds for the 14-inch gun and 50 rounds for the 12-inch mortar. It is assumed that a naval attack will not last more than approximately two hours; that the east and the west coasts will never be simultaneously in danger; and that the supply in the danger zone can be augmented by transfers from other parts of the coast. The allowances thus established have since been somewhat increased by the addition of 700-pound projectiles for certain mortar batteries.

The allowances for the insular possessions and the Panama Canal fortifications are double those for the continental

United States; that is, all guns and mortars are provided with sufficient ammunition to carry them through a two hours' engagement.

In addition to the regular allowance, the mortar batteries on Corregidor Island are to be provided with 80 rounds of shell and 150 rounds of shrapnel per mortar, for expected use against land targets.

### DISTRIBUTION

The ammunition allowances for all cannon mounted on the Pacific Coast and in the defenses of the Panama Canal and the insular possessions are to be kept in storage at the batteries.

For batteries on the Atlantic and Gulf Coasts 50% of the fixed ammunition and 50% of the propelling charges, together with 75% of the projectiles, are to be kept at the batteries.

### SUPPLY

#### *Insular*

Funds have been appropriated to date sufficient for manufacturing the greater part of the prescribed ammunition supply for the Hawaiian and Philippine armament. Ammunition has gone forward to the full value of the appropriations and, in addition, to the value of approximately $433,000 taken from the supply of the continental United States. Approximately $166,500 of this was rendered surplus by the transfer of the land defense guns previously referred to and will not have to be replaced.

#### *Panama*

The Panama Canal ammunition supply is in a satisfactory condition, as sufficient funds have been appropriated to provide the greater part of the prescribed allowance.

### STATUS OF LONG POINTED CAPS

Good progress has been made towards the work of adding long pointed caps to A. P. projectiles in the service. All the projectiles are now machined for receiving the caps, all range tables are ready, and sufficient caps are under manufacture for the projectiles pertaining to the armament of Hawaii, the Philippine Islands, and the Pacific Coast of the continental United States. Deliveries of caps are to commence next month [December, 1914], and are expected to be completed in about a year. When additional funds become available, about March 4, 1915, it is expected to place orders for caps for a considerable number, if not all, of the projectiles pertaining to the armament of the Atlantic and Gulf Coasts. All the projectiles pertaining to the Panama armament and all the 14-inch projectiles issued to the insular possessions were provided with long pointed caps at the time of their issue.

### MORTAR SHRAPNEL

The problem of providing a satisfactory time fuse for use in shrapnel for the 12-inch mortar has not been satisfactorily solved. A favorable offer was obtained from the Krupp Company for adapting their mechanical fuse to this purpose, but the placing of an order was prevented by the outbreak of the European war. In view of this delay, experiments are being continued with the powder time-train variety, but on account of the great variation in the atmospheric pressure during the time of burning in mortar fire, the Department is not very hopeful of success.

### MORTAR SHELL

There is now being developed a point fused, high explosive shell for use in land firing from 12-inch mortars. It is to be made of forged steel, but, by the omission of armor piercing requirements, can be produced somewhat cheaper than the service D. P. type. By means of the point fuse it is expected to secure quicker action than is possible with the base fuse. It is the aim to get such quickness of action as will give detonation before the projectile is completely buried in the ground. In firings from Corregidor Island with D. P. projectiles equipped with the standard delay action fuses, results were unsatifactory against land targets, because the projectiles buried themselves from 10 to 15 feet in the ground before exploding. A supply of quick-acting primers has since been forwarded sufficient for all probable needs for land firings with the projectiles on hand. It is doubted whether these will be sufficiently quick-acting, under the comparatively small retardation of land impact, to give satisfactory results, except for targets close to the point of fall.

### BOAT-TAILED PROJECTILES

A study of the problem involved indicates that if means could be found to break the practical vacuum existing at the rear end of projectiles in rapid flight, less loss of velocity, and therefore better exterior ballistics, would result. With a view to obtaining data on this point, a series of firings has been made at Sandy Hook, using 6-pdr. projectiles with tapered bases. Erratic flight was secured with those first tested; but this was later avoided by a change in dimensions giving a change in the position of the center of gravity with respect to the outline of the head. In the latest firings satisfactory accuracy was secured, but no improvement in ballistic efficiency. It has been surmised that this might be due to the taper of the base being too sharp for proper inflow of air, so additional firings are being undertaken to test out this theory.

### STICK SMOKELESS POWDER

Firings were made some months ago with a view to determining whether increased uniformity of velocities and pressures could be obtained with smokeless powder made in the form of long multiperforated sticks, these sticks being provided with side venting at short intervals with a view to avoiding blow pipe action at the ends. Tests were made in a 6-inch gun and in a 12-inch mortar. The results showed no significant difference between the behavior of this type of grain and that of the service powder, especially if the latter was made up in a single-bag charge with core igniter, to which matter I will refer later.

### EFFECT OF HARD ROTATING BANDS

A possible unusual hardness of the rotating band having been suggested as a cause for the high pressures occasionally obtained in firings from seacoast guns, a comparative test was recently made by firings from a 6-inch gun with projectiles equipped with service bands and with some especially hardened by excessive hammering. The results showed no marked difference in the velocities and pressures, although the variations were somewhat greater with the hard bands. A curve giving the mean values of the maximum pressures as a function of the hardness, showed a tendency to lower rather than to higher pressures with the harder bands. In connection with this investigation, hardness tests were made of a considerable number of bands on projectiles at Watertown Arsenal and in the Northern Armament District without finding any of excessive hardness.

### SINGLE-SECTION POWDER CHARGES

There is under consideration at the present time the question of adopting for use in all large caliber guns a powder charge made up in a single section, in lieu of the usual two to six sections, in so far as handling facilities will permit.

The single section would be equipped with a core igniter running through the center of the charge and with a small one of the usual form at each end. The results of tests, except for one series of 12-inch firings, in which case the powder was too slow for the gun, have indicated a decided improvement in uniformity of velocities and pressures with the single-section charge. On account of the limited data available, about five rounds for each caliber with the proposed form of charge, and on account of the one poor record, it was decided to make further firings before coming to a decision. These firings have not yet been completed.

In connection with the additional firings ordered, some rounds are to be fired with charges made up in sections as at present, but equipped with core igniters having the ends covered with a loosely woven material permitting the ready passage of the flame from one section of the charge to the other.

The adoption of the single section charge would evidently involve the providing of new cartridge storage cases and special means for handling the charges at the guns. It is probable that both ends of the cases would be made removable, so that the charge could be rammed from the case into the gun.

### HIGH PRESSURES IN SERVICE

The investigations in progress with a view to ascertaining the cause or causes of the high pressures that have been encountered in a few instances in service and at the Sandy Hook Proving Ground have, it is understood, been rather fully covered by Major F. K. Fergusson in his recent lecture before the school. It is sufficient to state that no satisfactory explanation has yet been found, but it is hoped that a side impact drop test recently developed may furnish a means for readily detecting lots which are liable to prove objectionable.

It may be further stated that the trouble has been confined to only a very few lots of powder out of the large number in service and that steps have been taken to stop the use of, or to withdraw from service, every lot that could be considered in any degree suspicious.

### TARGET PRACTICE: MUZZLE VELOCITIES

With a view to better analyzing the behavior of smokeless powder in service, there has been plotted for each target practice year from 1911 to 1913 inclusive, the muzzle velocities assumed at each practice as a result of the trial shots. These data have been plotted both as a function of the location of the target practice and as a function of the age of the powder used. From the plotted data for each year mean curves were constructed for each caliber, thus enabling general conclusions to be deduced therefrom. Considering the target practice for the year 1913, the mean curve for the 8-inch velocities as a function of the location of the firing, indicated that a muzzle velocity of approximately 125 feet per second lower than the standard for the gun was everywhere assumed. This result led to an investigation of the range table for that gun. Firings made for that purpose showed that approximately 96 feet per second of this apparently low velocity was accounted for by an error in the range table. This error was found to have arisen in the computation of the table through giving too much weight to the value of the ballistic coefficient as determined for the 10-inch and 12-inch guns in adopting a ballistic coefficient for the 8-inch. The later firings confirmed the accuracy of the ranges obtained in the earlier firings upon which the range tables were based, but which data were modified as already indicated. In view of the expected early issue of long-pointed caps for the 8-inch gun, and in view of the accuracy of the recently computed range table for that type, it has not been considered necessary to modify any 8-inch elevation scales.

The mean curve for the 12-inch gun indicates that the velocity was assumed to be below the standard by about 75 feet per second in practically all artillery districts, except in the Philippine Islands, where it was assumed to be about 25 feet per second above the standard. Recent firings at Sandy Hook Proving Ground seem to indicate that there is a small error in the 12-inch range tables resulting in an indication of velocities by approximately 14 f.s. less than are actually secured.

The mean curve for the 10-inch gun indicates that the velocity was assumed as approximately 35 feet per second below the standard, regardless of the place of the firings. The accuracy of the 10-inch tables was verified as set forth in the Report of the Chief of Ordnance for 1910.

The curves showing the variations from the standard in the muzzle velocity assumed for target practice when plotted as a function of the age of the powder show that the 8-inch powder of newest manufacture gave slightly higher velocities than powders of oldest manufacture, the difference being approximately 25 feet per second between that manufactured in 1901 and that manufactured in 1911. The 10-inch and the 12-inch powders of newest manufacture gave somewhat lower velocities than those of oldest manufacture. For the 10-inch there was a difference of about 25 feet per second between that manufactured in 1904 and that manufactured in 1911. For the 12-inch there was a difference of approximately 40 feet per second between that manufactured in 1902 and that manufactured in 1911. The oldest used and the newest used were as specified above. The plotted records do not, of course, indicate the variations in muzzle velocity at any individual practice, but merely what velocity was assumed by the battery commander for that practice.

## ACCESSORIES

### PRIMERS

There are three types of primers now in service for firing seacoast cannon not using fixed ammunition, namely, combination electric-friction, single-wire simple electric, and simple friction. It is expected that no more combination primers will be manufactured, and that the single-wire electric type will be replaced by a two-wire type, provided a satisfactory primer of the latter type can be developed. A great deal of attention has been devoted to the development of such a type and many samples have been tested, but there are inherent difficulties in the way of securing satisfactory contacts for a two-wire type. The suggested use of two flexible wires to be connected to binding posts or plugs in connections on the breech was found seriously objectionable, because it permitted the firing of a primer before the slide of the firing mechanism had been lowered to prevent the primer from being blown to the rear. The most promising principle is one now being tested in which the button contact is retained for one terminal and a flexible wire is lead through the primer stem for the other.

In order to reduce the chances for an accidental break in the present firing circuits, the connections at both ends of the short firing cable attached to the breech of the gun have been recently modified. In this change, a screw nut and lock washer have been substituted for the split-plug contact on the firing mechanism, and the other end of the short cable has been soldered directly to the plunger which makes contact across the safety break at the outer edge of the block. This was formerly attached to the plunger housing by means of a forked spring connection.

The only apparent disadvantage of the changes is that they reduce the ease of disassembling the firing cable.

### MAGNETO FIRING MECHANISM

The proposed magneto firing mechanism, using a hand operated alternating current generator to furnish power through a transformer near the breech of the gun, has been given an extensive trial during the current year's target practice, but not many reports have yet been received covering its behavior.

This test has also included improved single-wire primers and the improved cable connections previously referred to.

The results thus far reported have been favorable to all parts of the system.

### ALTERATION OF FUSES

The following changes have been ordered made in detonating fuses, and the work is nearing completion:

(a) The torpedo detonating fuse is being eliminated by alteration to make it similar to the A. P. detonating. The latter type of fuse is ordinarily designated as having a modified Peirce stock, but that designation can properly be dropped, due to the fact that there is only one type of stock in use with that type of fuse.

(b) All siege detonating fuses are being modified to conform, except for slight exterior dimensions, to the standard medium caliber base detonating fuse. The medium caliber fuse can be used in projectiles prepared for the siege detonating fuses by using a thin washer, or adapter, under the head. All siege detonating fuses on hand have been assigned to 6-inch A. P. shell. All other 5-inch and 6-inch projectiles are equipped with the medium caliber base detonating fuse.

As a result of the modification of torpedo detonating fuses, all projectiles for guns and mortars of 8-inch caliber and above are now equipped with either the major caliber base detonating fuse or the A. P. detonating fuse. These types of fuses are not interchangeable but are readily distinguishable by the much greater diameter and length of the A. P. detonating type. As regards the plungers and detonators, there is but one type of each in both types of fuses assigned to major caliber projectiles, and one type in both types of fuzes assigned to 5-inch and 6-inch projectiles.

For use in 6-pdr. projectiles there is a small fuse known as the minor caliber base detonating fuse. This is provided with a ring resistance plunger. This is necessary on account of the small space available, and is not objectionable in view of the great acceleration to which this projectile is subjected, which permits a large factor of safety against accidental arming.

The centrifugal plunger in use has proved to be very safe in transportation and handling, and certain in action. Restraining springs, acting against the plunger, are used to keep it away from the primer in flight. This avoids possible prematures during that time and gives greater certainty of action, by the blow coming from the movement of the plunger after impact. All A. P. shot and D. P. shell are being equipped with delay action primers, while all A. P. shell and torpedo shell are equipped with quick action primers. However, in view of the possibility of D. P. shell being used for land defense purposes, a supply of quick-acting primers is being issued to mortar batteries to be substituted for the delay primer for land defense use.

In overhauling the fuses, a quick-acting primer of improved type is being substituted. Tests have indicated that this will give greater quickness of action and will have better keeping qualitites than the one previously in use. The restraining springs are also being strengthened, as this change has been found to increase quickness and certainty of action on impact.

## The 14-inch Gun

### HISTORY OF ITS DEVELOPMENT

The following is a brief history of the 14-inch gun's development in so far as concerns the army:

The first appropriation applicable to the purchase of 14-inch guns was approved March 2, 1907. The work of designing a gun was undertaken and orders placed December 20, 1907, for one 14-inch wire-wrapped (Model of 1907) and two 14-inch built-up (Model of 1907 MI) guns, all of these being 34 calibers long. They were designed for a muzzle velocity of 2150 f.s., and were intended to have at least equal power with the 12-inch 2500 f.s. gun, which had been tested and found to have too short an accuracy life to be satisfactory for service, it being only about 50 rounds with the narrow bands then in use. It was believed that the 14-inch gun would have an accuracy life of at least 250 rounds, which has proved to be the case. At that time, there appeared no need for a more powerful gun than the 12-inch to be replaced. Due to the later marked tendency towards increased thickness of armor, the 40-caliber 14-inch was laid down, known as Model of 1909, for the turret guns, and as Model of 1910, for guns on disappearing carriages. These were intended to have a muzzle velocity of 2250 f.s. In view of a continued tendency towards increased thickness of naval armor and towards increased numbers of large caliber guns, a further advance is being made by an enlargement of the powder chamber in these types as well as in the Model of 1910 MI guns under construction. This gives an increase of 110 feet in the muzzle velocity; that is, a muzzle velocity of 2360 f.s. for all the Philippine guns, except two of the Model of 1907 MI, and for all the Panama guns. It having been demonstrated that the muzzle droop can be kept within satisfactory limits, there is now being prepared a design for a 14-inch 50-caliber gun having the large chamber capacity. With this a muzzle velocity of 2525 f.s. can be secured with a 1660 lb. projectile or one of 2750 to 2800 f.s. with a 1400-lb. projectile.

### MODEL OF 1910 MI

The drawing herewith shows the 14-inch guns, Model of 1910 MI, now under manufacture. As compared with the Model of 1907, there has been an increase in length and in the capacity of the powder chamber. As compared with the Model 1910 there has been a modification of the chase hoops, with a view to securing increased stiffness, a thickening of the B tube, and a change in the material of the jacket and of the B tube from gun steel to nickel steel. The increase in the capacity of the powder chamber will result in an increase in the muzzle velocity from 2150 f.s. to at least 2360 f.s., with the standard weight projectile—1660 pounds. The latter velocity corresponds to 2570 f.s. with a 1400-lb. projectile.

It will be noted that the outer layer of the gun is made up of three parts only: the jacket extending from the breech to slightly beyond the center line of the trunnion hoop; a chase hoop extending from that point about half the length of the chase; and a second chase hoop extending the remainder of the distance. A long overlap is provided between the chase hoops, which, together with the shrinkage of the heavy trunnion hoop over the joint between the jacket and the other chase hoop, is expected to give great transverse stiffness and little muzzle droop. The thickening of the B tube and the change of material to nickel steel, are intended to better resist elongation. The thickening also serves to increase the stiffness. In order to increase the factor of safety of the jacket against longitudinal pull, the material has been changed to nickel steel. The foregoing changes serve to increase the cost of the gun considerably as compared with the model 1910, but the results are believed to justify the increased cost.

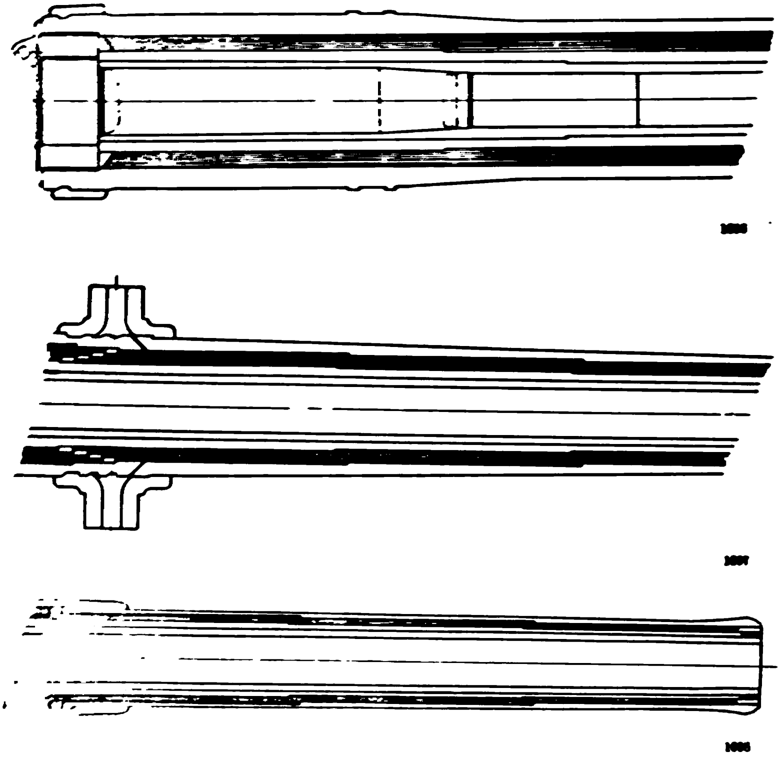


Fig. 3.
14-inch gun, model 1910 MI.

### NAVAL MODELS

An examination of data in Brassies' *Naval Annual*, and other publications, indicates that there is no 14-inch gun in service in any country of greater length than 45 calibers. Designs for 50-caliber guns have been prepared for use in the United States and a few other countries, and it is possible that the work of manufacture has been in some instances undertaken.

### ABILITY TO ATTACK WARSHIP ARMOR

Considering foreign warships as being the ones of most concern to the Coast Artillery, a recent publication has stated that the water line armor has increased in thickness as follows, within the past eight years:

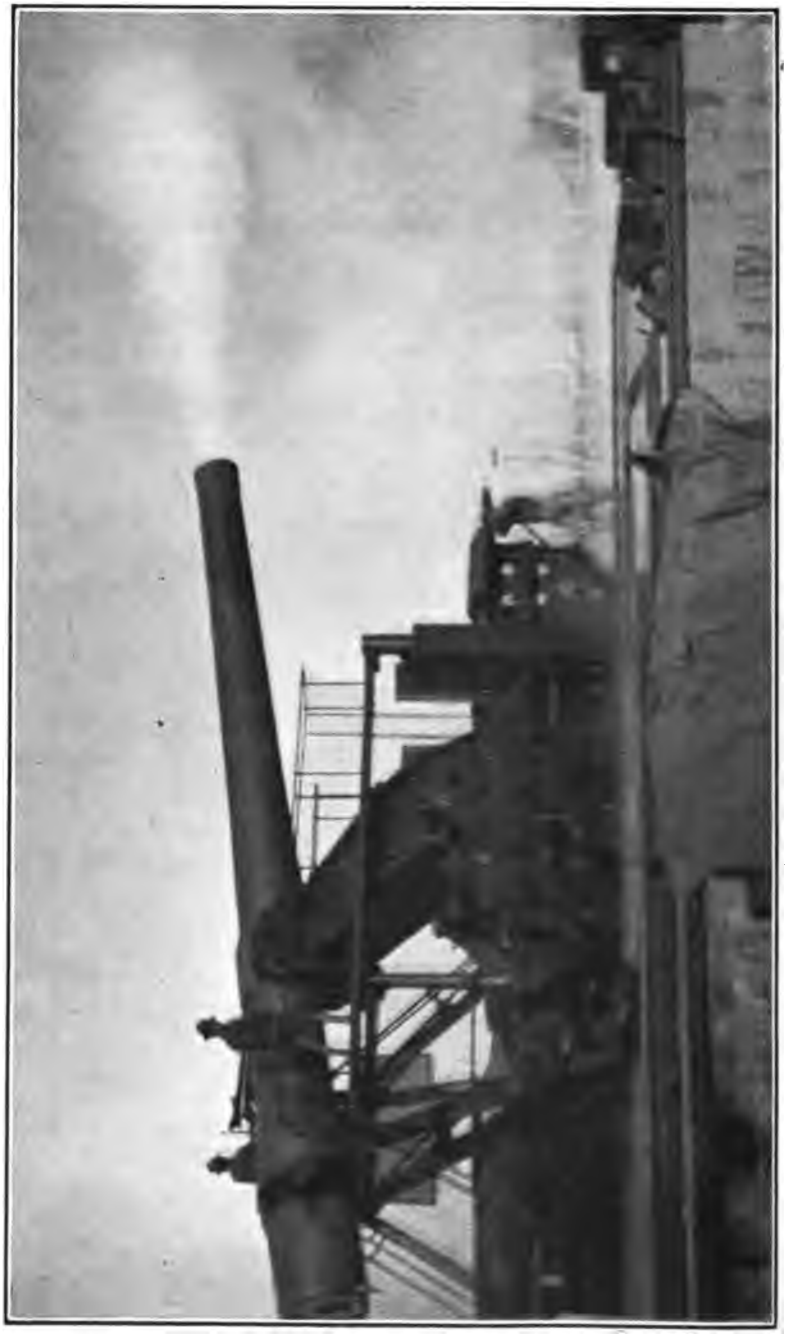
France, from 10 to 12 inches,
England, from 10 to 13-½ inches,
Germany, from 12 to 15 inches.

The large chamber 14-inch 50-caliber gun now being laid down, is believed to satisfactorily meet this advance. Thus a 1660-lb. projectile with a muzzle velocity of 2525 f.s., will, theoretically, perforate the following thicknesses of K. C. armor:

| Range, Yards. | Normal Perf. Inches. | 30 deg. Perf. Inches. |
|---|---|---|
| 5000 | 21.5 | 19.7 |
| 10,000 | 17.5 | 16.1 |
| 15,000 | 13.6 | 12.5 |

### TIME REQUIRED TO BUILD

In view of the fact that a 14-inch gun, Model of 1907, was not issued to the service until June, 1913, it seems proper to set forth that it ordinarily requires from two to two and a half years in which to build a 14-inch gun. This is illustrated by the fact that the first 14-inch gun, Model of 1907 (wire-wrapped), was ordered December 20, 1907, and was completed and forwarded to the Proving Ground on or about August 15, 1909; that is, one year and eight months later. The work on this gun was rushed more than would ordinarily be the case.



1808

FIG. 4.
14-inch gun on disappearing carriage.

The normal time of completion, with the shops not overcrowded with work, would be about two years. For the past three or four years, the Watervliet shops have been so overcrowded as to materially increase the time of construction of a given gun.

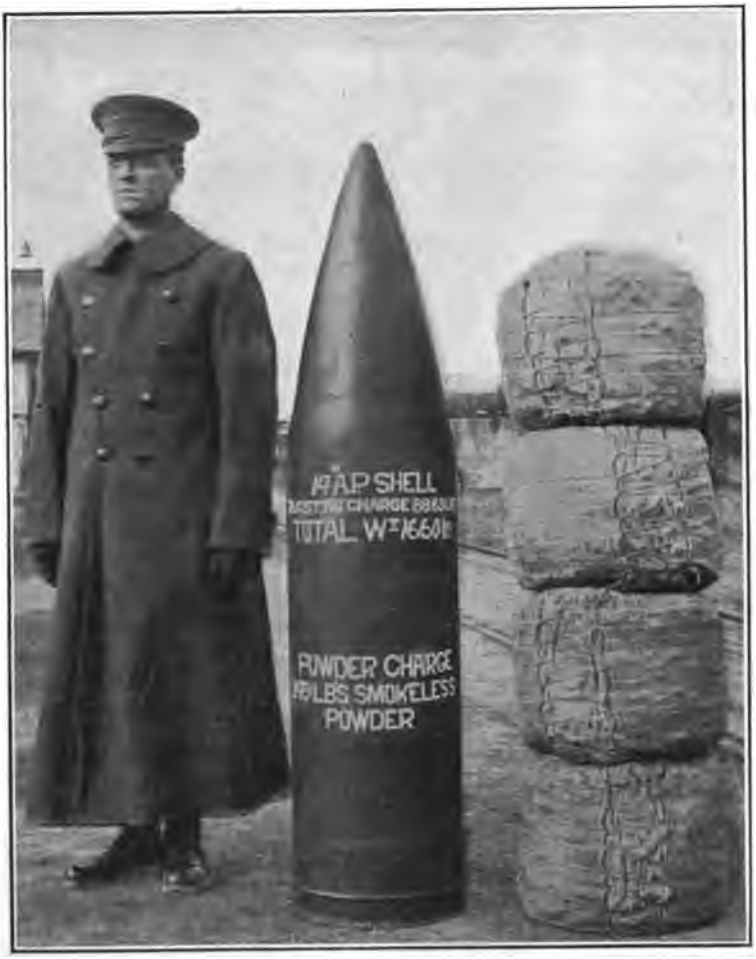


FIG. 5. 1610

14-inch projectile and charge.

### GUN AND CARRIAGE FOR PANAMA

The illustration herewith (Fig. 4) shows a 14-inch gun being fired from a disappearing carriage of the type being mounted in the Panama fortifications and in the insular possessions. You will note a large volume of what appears to be

[illegible]

are no data available bearing directly upon the question as to how much the accuracy life would be lessened through the securing of a higher muzzle velocity by a mere lengthening of the gun from 40 calibers to 50 calibers. It is assumed, however, that this lessening of accuracy life would not be great. The accuracy life of the service 40-caliber gun has been ascertained to be at least 250 rounds—possibly as many as 300. The objections to a longer gun are, then:

(a) Increased cost, and
(b) Increased muzzle droop.

As regards increased cost, it is estimated that an increase from 40 to 50 calibers involves an increase of approximately 15 per cent in the cost of the gun and in the cost of the disappearing carriage which would afford protection equal to that now secured with the shorter gun. It is believed to be a common view in the Coast Artillery that longer guns cannot readily be used on disappearing carriages; but this view is fallacious, as is evident from the fact that 12-inch, 14-inch, and 16-inch guns are used with equal protection for all.

As regards muzzle droop, this defect has not thus far proved serious with any of the 14-inch guns. The latest model has materially less droop than the earlier ones, the improvement resulting chiefly from longer chase hoops and better overlaps to secure rigidity.

### MUZZLE VELOCITY AS AFFECTED BY CHAMBER CAPACITY

An increased muzzle velocity can be secured up to a certain limit, by increasing the chamber capacity without increasing the total length of gun; but this results in a rapid decrease in accuracy life. While the available data are not entirely consistent, it is believed that an increase in the chamber capacity by 28.6%, which has been effected for the later 14-inch guns, will result in a decrease in accuracy life by something like 50 %. It is therefore estimated that a 14-inch gun with the larger chamber will have an accuracy life of from 125 to 150 rounds, as compared with one of 250 rounds for the smaller chamber gun.

The accuracy life of the large chamber gun when fired with full velocities, is then less than twice the probable number of rounds fired in a two-hour engagement, and therefore probably too short to justify its habitual use in target practice with full velocities. If, however, it be used at target practice with the present service velocities, 2250 f.s., the accuracy life would be fully as great as that of the small chamber gun now used. The logical procedure seems, then, to build large chamber, long guns, and use them with reduced velocities at target practice, but with high velocities for war service. The design of a 50-caliber 14-inch gun with a chamber capacity of 19,300 cubic inches is now under way.

## TURRETS

In view of the fact that there seems to be considerable sentiment in the Coast Artillery Corps favoring the use of turrets in lieu of disappearing carriages for future armament, I will outline briefly what appears to me the relative merits of those types of mounting.

The turret has the evident advantages of giving overhead protection from ordinary fragments of projectiles and of concrete, and from aeroplane bombs and howitzer fire, except from very heavy bombs or projectiles from very large caliber howitzers. It also gives protection against fire from the rear, and affords an all-round field of fire.

The most evident objections to the turret, beyond the complicated machinery involved, are the great cost per gun and the large target it affords the enemy.

As regards cost, a rough estimate has been prepared by the Ordnance Department and the Engineer Department indicating that the combined cost of gun, mount, and emplacement for a site such as Cape Henry is $530,000 per 14-inch gun for a turret system, and $308,000 for a disappearing carriage system. These estimates are based on single-gun emplacements for disappearing mounts and two-gun turrets for the other system. This means that approximately seven 14-inch guns could be installed in single gun emplacements on disappearing carriages at the cost of four guns mounted in two turrets. The cost per gun for turret guns would be somewhat decreased if three-gun turrets were employed, and would be greatly increased if single-gun turrets were employed.

As regards the size of targets presented by the two systems, that afforded by the gun on disappearing carriage during the few seconds that it remains in the firing position, is not much greater than that afforded by the portion of the gun protruding from a turret, but which remains always exposed to fire.

A projectile just missing a gun on a disappearing carriage will probably do no harm, whereas one that just misses a gun projecting from a turret may enter the port and put one or both guns out of action. That the jamming of a turret by a single lucky shot has happened in action in a number of instances, is shown by the following extract from an article by Lieutenant White, U. S. Navy, entitled, *With the Baltic Fleet at Tsushima*, in which he says:

> Only three shots were fired from the forward turret of the *Osliabia*. A shell struck the embrasure beneath one gun and, exploding, jammed the gun in extreme elevation and lifted the top of the turret.

Later on in the same article he states:

> Early in the action a shell struck the embrasure in the forward turret of the *Suvaroff*, exploding and igniting several bags of powder. The roof was blown completely off and landed on deck, leaning against the turret.

Later on, he speaks of the 6-inch turrets in the *Orel* being disabled by the explosion of a shell (*Proceedings Naval Institute*, 1906). In a discussion of the battle of Santiago, as given in Brassey's Annual, 1899, the following occurs:

> One shell struck and exploded at the forward turret of the *Oquendo* between the gun and the curved upper shield, killing the men inside and jamming the turret.

That a land turret can be sufficiently thick to prevent probable penetration by projectiles is not doubted; but this will not avoid the possibility of the turret's being jammed by a blow upon it, of the machinery's being disabled from other causes, or of a projectile's entering by way of an embrasure port.

It is believed, moreover, to have been shown by actual experience in recent wars that the mere shock from the impact and detonation of a heavy projectile on the exterior of a turret is sufficient under certain conditions to put out of action the entire detachment within the turret.

As regards cost, it is evident that no expense should be spared, the results of which are commensurate with the outlay; but it is not clear that the substitution of turrets for the disappearing type of mount would, on the whole, be justified. It seems probable that much information of value directly bearing on the efficiency of turrets will be obtained in connection with the operations of the war now in progress in Europe.

### EXTREME RANGES

With a view to ascertaining what extreme range could be obtained with service 12-inch guns, through the use of lighter weight projectiles, firings were made at the Sandy Hook Proving Ground with a 700-lb. projectile of the type being furnished for 12-inch mortars. It was found that a muzzle velocity of 2700 f.s. can be readily secured with this weight projectile. In one round fired at 14 degrees 30 minutes elevation, an actual measured range of 20,216 yds. was secured with a muzzle velocity of 2790 f.s.

Computations indicate that a 14-inch, 40-cal., large chamber gun will give a muzzle velocity of 2775 f.s. with a 1200-lb. projectile, this being about the weight used, to at least some extent, in the French Navy. With such a projectile and muzzle velocity, a maximum range of something more than 21,000 yards can be secured. That secured with a velocity of 2360 f.s. and a 1660-lb. projectile is slightly more than 19,000 yards, which extreme range is probably sufficient for all practical purposes. The curves herewith (Fig. 7) show the armor perforation as a function of the range for 12-inch projectiles of 700-lb. and 1070-lb. weight, respectively, fired from service 12-inch guns, and that of 1200-lb., and 1660-lb. projectiles fired from a large chamber 14-inch, 40-cal. gun. It will be noted that the armor penetration for the 12-inch gun is greater for the light weight projectile up to approx-

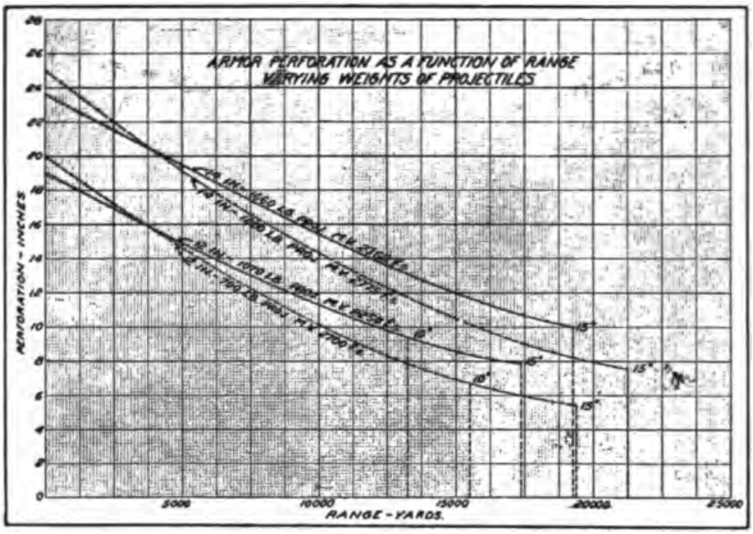


FIG. 7.

1612

imately 3600 yards, but drops off materially for ranges beyond that point. The armor penetration for the light weight 14-inch projectiles is greater up to approximately 4100 yards, and drops off beyond that range. The most important advantage of the heavy weight projectile, beyond its increased armor penetration at the longer ranges, is its increased strength and capacity for high explosives. The importance of scrutinizing weights of projectiles in comparing muzzle velocities of guns of different manufacture is not always fully appreciated, and it is desired to emphasize that point in this connection.

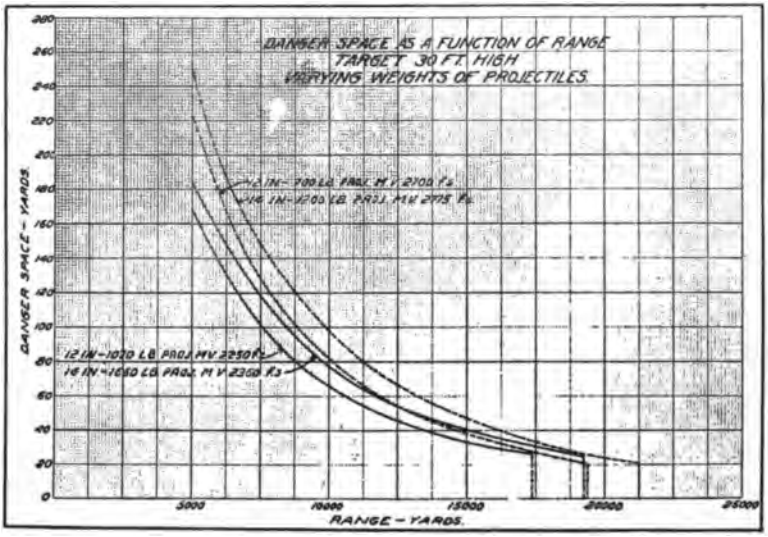


FIG. 8. 1613

## DANGER SPACE

The curves herewith (Fig. 8) show the danger space as a function of range for a light weight and a heavy weight 12-inch projectile and for a light weight and a heavy weight 14-inch projectile, respectively, fired from service guns with such velocities as can be readily secured. It will be noted that at the range of 5000 yards the danger space for a 12-inch standard weight projectile is 168 yards, in comparison with a danger space of 222 yards for a 700-pound projectile. At the same range the danger space for the 14-inch projectile is 184 yards for the 1660-pound, and 250 yards for the 1200-pound types. At 10,000 yards the danger spaces are: 12-inch 1070-lb. projectile, 66 yards; 12-inch 700-lb. projectile, 80 yards;

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 150-grain projectile, 46 yards. Beyond these ranges the danger spaces will be correspondingly less.

The advantage in increased danger space as secured with the light weight high velocity projectile thus becomes small at the long ranges, where most important.

The increased danger space for the light weight projectile is believed to be more than offset by its reduced strength and by its reduced armor penetrating power beyond about 600 yards, as previously pointed out.

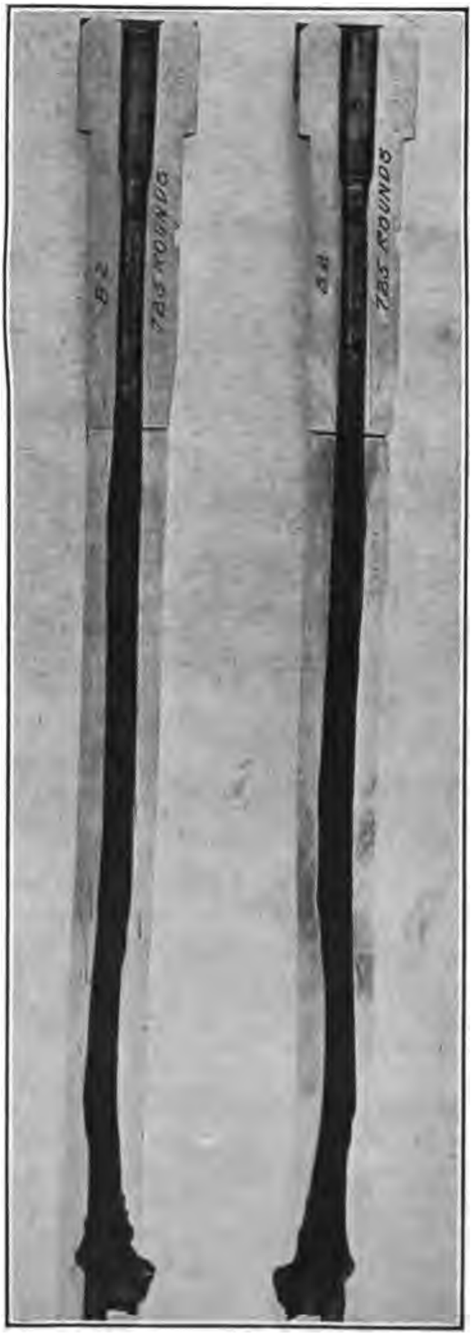
## EROSION TESTS: .30 CALIBER RIFLES

In an attempt to develop a steel for large caliber gun liners which would be more resistant to erosion than the types in common use, an extensive series of firings was conducted with .30 caliber automatic machine gun barrels made of various qualities of steel. These efforts have not thus far resulted in finding a steel more resistant to erosion than the plain carbon steel now in use, but the tests have rather clearly demonstrated the superiority of that steel over all the other steels tested. The nickel steel sometimes used for gun liners, was found inferior in this series of tests. The results are, however, not considered conclusive as applied to large caliber guns. The Department has accordingly had a number of 10-inch and 12-inch guns relined with gun steel and with nickel steel liners, respectively, in order thus to secure more conclusive data.

In the machine gun tests, ammunition using nitroglycerin powder was employed and firings were made as rapidly as possible, in order to secure erosive results as great as practicable with a limited expenditure of ammunition. The illustrations herewith (Figs. 9, 10, and 11) show the interior of a number of the barrels at the conclusion of the firings.

The two long barrels were used in firings where the water jacket was not filled (Figs. 9). Attention is invited to the great enlargement some distance down the barrel of the two used without water. It will be noted that in one instance this enlargement progressed to a point where the projectile [illegible] through the side of the barrel.

[illegible] firings with the short barrels, the water jacket was [illegible] each series of rounds; the results are, therefore, [illegible] comparable.



1614

Fig. 9a.

Erosion Tests.

.30 caliber barrels, nitroglycerin powder, rapid fire, water jacket not filled.

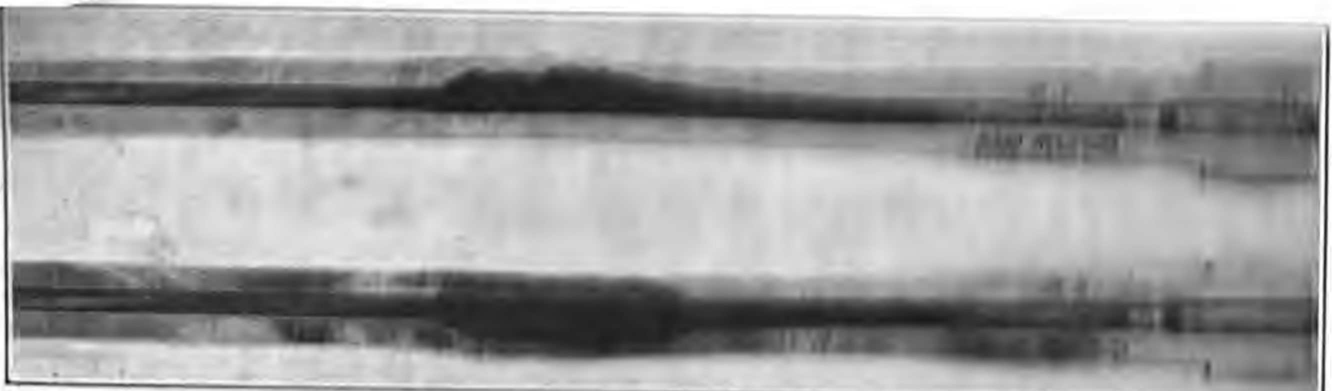


Fig. 9 b

1919

Erosion Tests

.30 caliber barrels, nitroglycerin powder, rapid fire, water jacket not filled

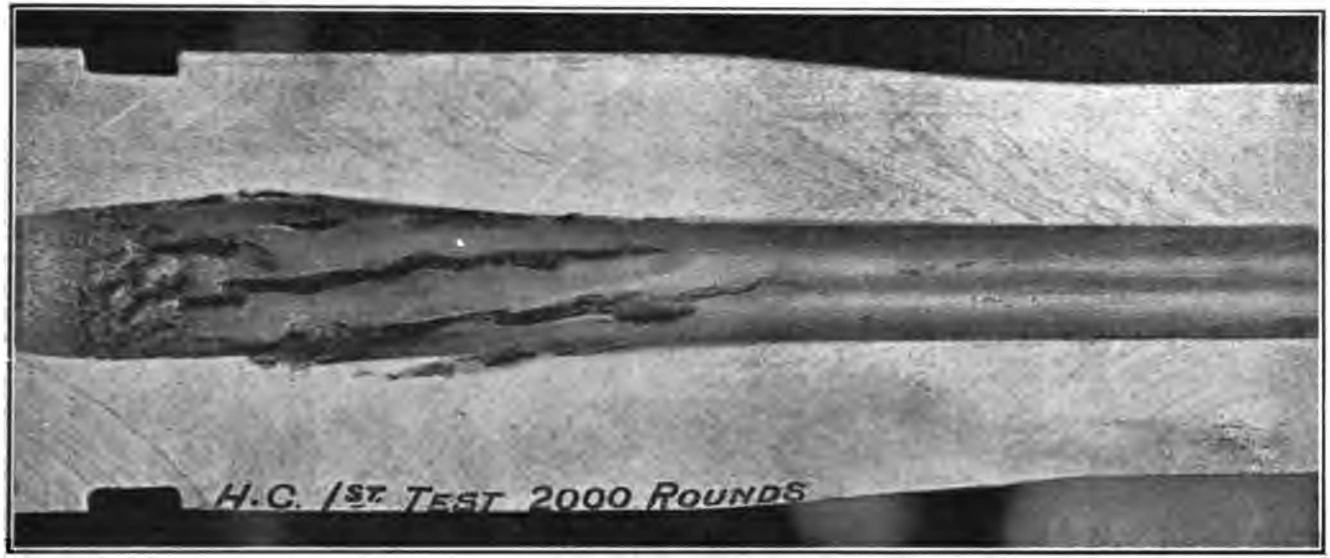


FIG. 10 a.

EROSION TESTS.

.30 caliber barrel, nitroglycerin powder, rapid fire, water jacket filled.

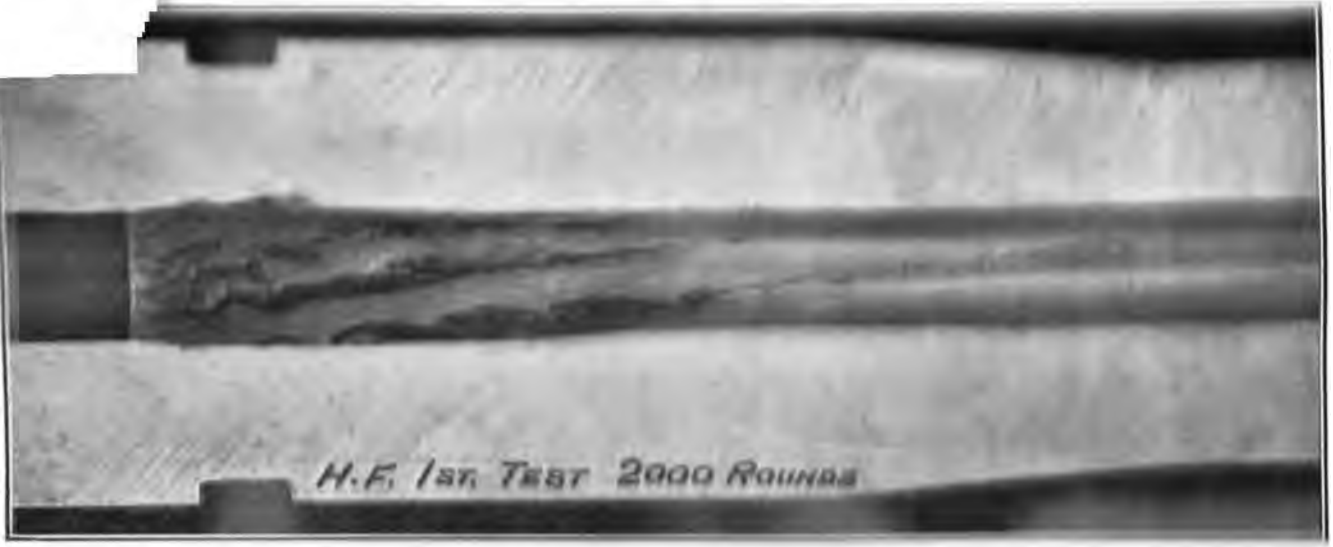


Fig. 10 b.

Erosion Tests

.30 caliber barrel, nitroglycerin powder, rapid fire, water jacket filled.

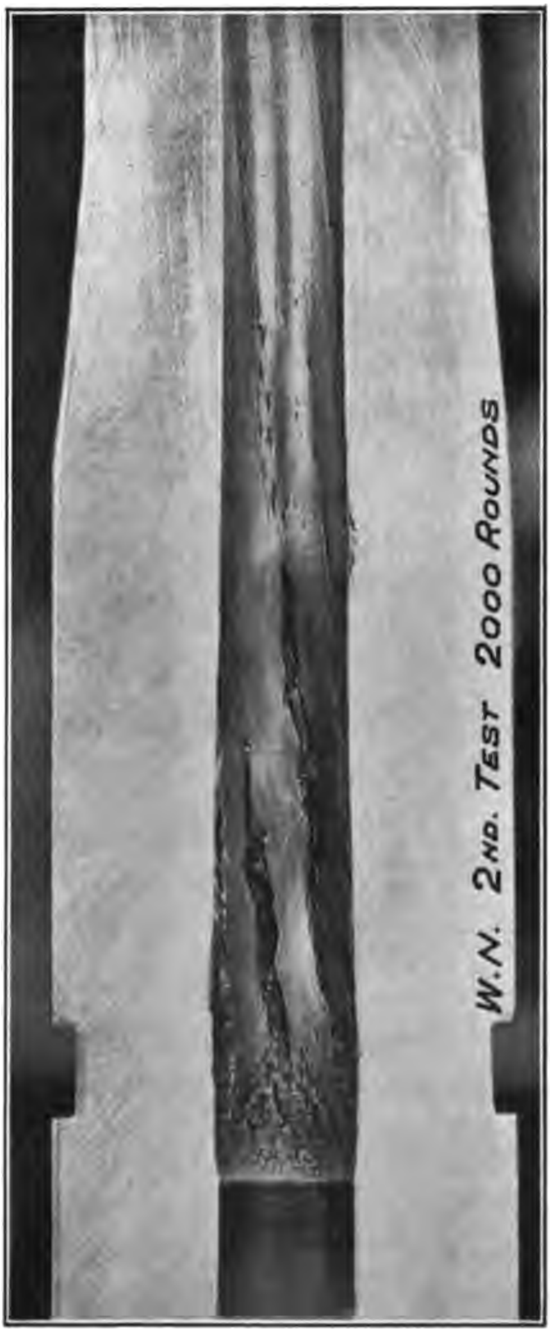


FIG. 10 c.

EROSION TESTS.

.30 caliber barrel, nitroglycerin powder, rapid fire, water jacket filled.

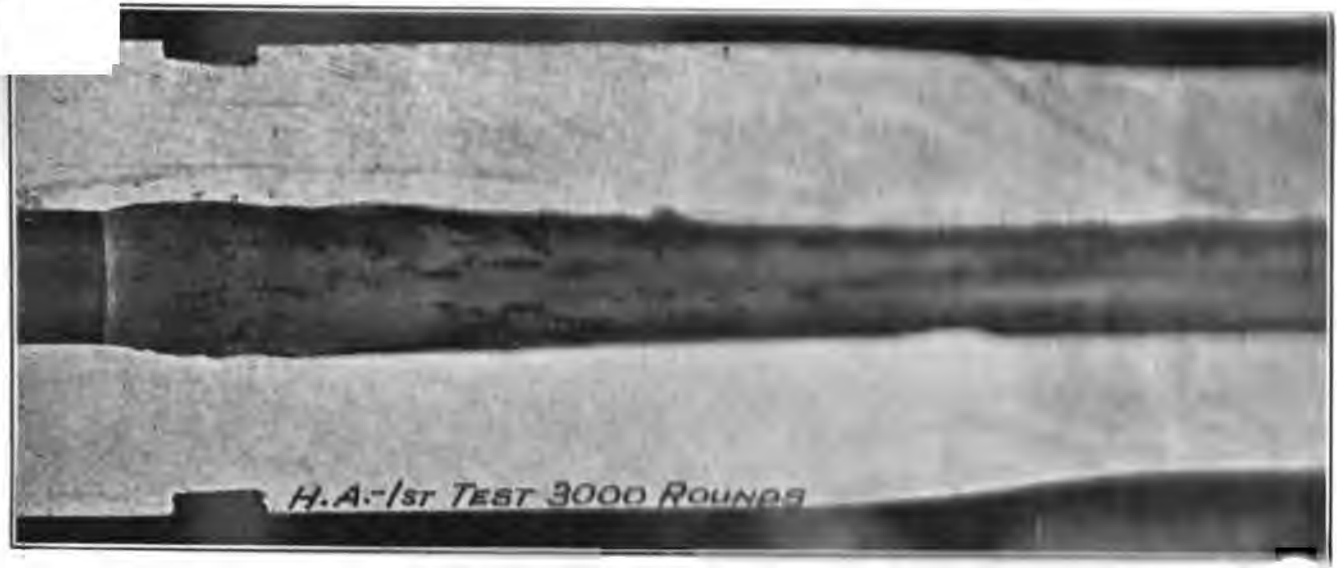
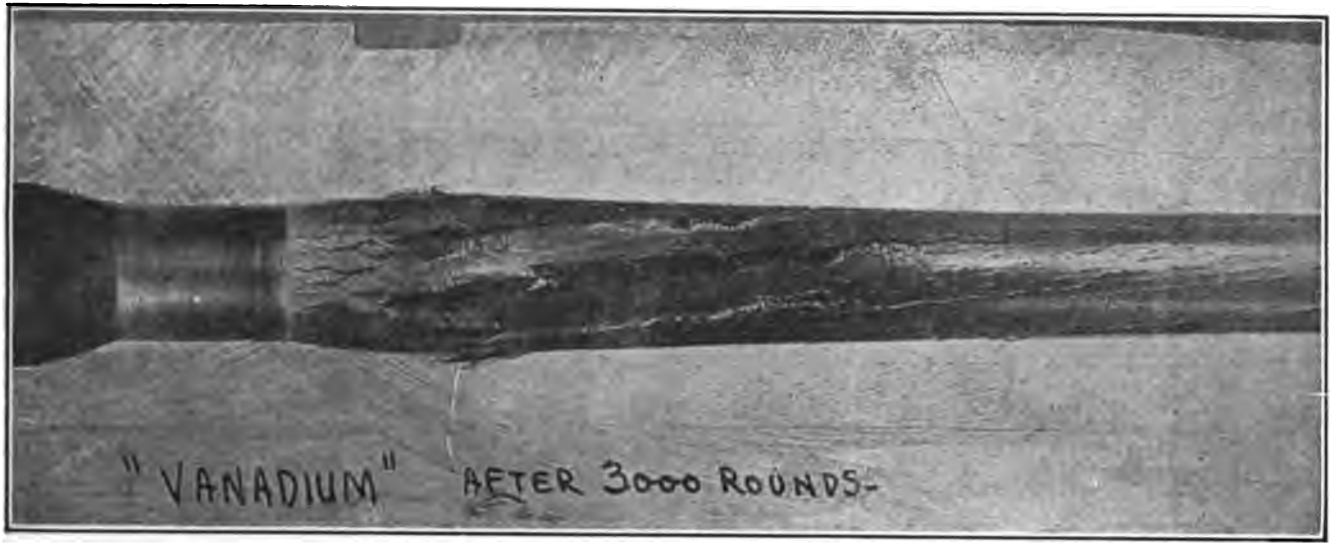


Fig. 11 a.

Erosion Tests.

.39 caliber barrel, nitroglycerin powder, rapid fire, water jacket filled.



1620

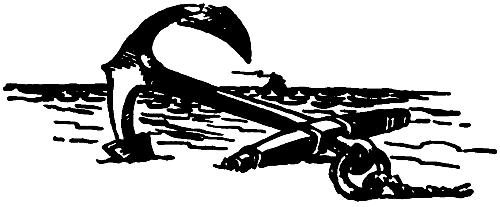
FIG. 11 b.

EROSION TESTS.

.30 caliber barrel, nitroglycerin powder, rapid fire, water jacket filled.

One set of shorter samples (Figs. 10) shows a nickel steel, W. N., and two imported steels, H. F. and H. C. The firings with these were suspended after 2000 rounds, the erosion being apparently excessive. Its character is clearly indicated in the photographs.

The other set of shorter samples (Figs. 11) shows a gun steel (W. G. 2), a tool steel (Vanadium), and an imported steel (H. A.). All of these were fired 3000 rounds. It will be noted that the gun steel is in somewhat better condition than any of the others in this series and better than those in the other plate, which had been fired 2000 rounds as compared with 3000 rounds for the gun steel.



by water or great changes in temperature. It has a very high current carrying capacity, and, therefore, can take a great deal of power. I personally saw two and three kilowatts used in this machine without any marked heating effect. It was reported to me shortly after this test that sufficient energy had been utilized by the machine to shatter a composition diaphragm whose thinnest part was over an inch thick. From the above data, it can be readily seen that practically unlimited power can be used efficiently to generate sound in water. For the distances that shore-tug work would require, the amount of power necessary should not be over three or four kilowatts, at the most. With this amount of energy, and under normal conditions, there should be no trouble in transmitting the Morse code under water at a rate of twenty-five words per minute to a distance of nine or ten miles.

There are three practicable methods that can be used in shore-tug signalling:

1. Visual signalling.
2. Radiotelegraphy.
3. Submarine signalling.

In some special cases, for short distance work, sound signals in air could be utilized. However, this method is very impracticable owing to the weakness of the sound signals to be expected at any great distance, and also to the foreign noises that would probably interfere with the operator. Radiotelegraphy were ideal for this work, were it not for the great amount of interference experienced in using that method. At present, there are such a great number of commercial and naval stations in the vicinity of most of our fortifications that it is very difficult to find a time when you can communicate with the tug from shore, or *vice versa*, without interference from one or more of those stations. Such interference is the cause of a great deal of worry and loss of time.

Water has a great many advantages over air for purposes of signalling:

1. It is free from the dangerous zones of silence which occur when signals are produced in air.

2. Absorption of sound is much less in water, and consequently the signal is not only absolutely reliable, but is transmitted to a distance many times greater than when it is transmitted through air.

3. The sound is not carried away by the wind in stormy weather, as is the case with the siren.

4. The sound is not affected by atmospheric disturbances, as in the case of radiotelegrapy.

5. Water permits of the accurate determination of the direction from which the sound is proceeding, which is not the case with either the air siren or wireless telegraphy. (This should be of value in locating the exact position of various picket boats during night practice.)

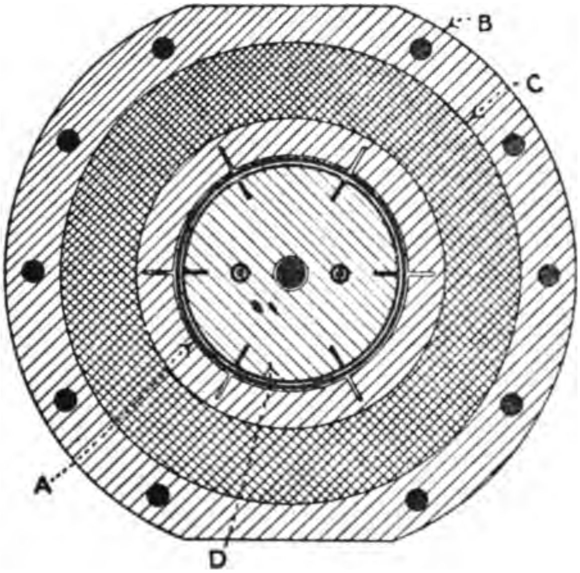


FIG. 1. 1833

It is possible by using the oscillator to have several control stations from which messages could be sent and received. Thus, the umpire, the safety officer, the battery commander, the fire commander, the fort commander, and the coast defense commander could all be in instantaneous communication with the tug officer, without first telephoning the message to the wireless operator, as is the case in using radiotelegraphy. In other words, submarine signalling has the advantage of having a more flexible method of communication than radiotelegraphy. This, together with reduction of interference from nearby radio stations, should give the water signals a marked advantage over the present methods.

The following is a description of the oscillator invented Professor Fessenden:

The device used to propagate sound under water is termed an oscillator and its construction is shown in cross-section in Fig. 1. In the figure, the iron of the magentic circuit and the copper tube are shaded. The magnetising coil is crosshatched. The moving part is the copper tube A. This lies in the air gap of a magnetic field, as is seen, formed by a ring magnet, B, built up in two parts, as shown in longitudinal section in Fig. 2.

The ring magnet is energized by the coil C, and produces an intense magnetic flux, which flows from one pole of the ring magnet across the air gap containing the upper part of the copper tube, thence through the central stationary armature, D, thence across the other air gap to the lower pole face of the ring magnet, and thence through the yoke of the ring magnet back to the upper pole face. This field is very much stronger than that in the ordinary dynamo, there being more than fifteen thousand lines for each square centimeter of cross section.

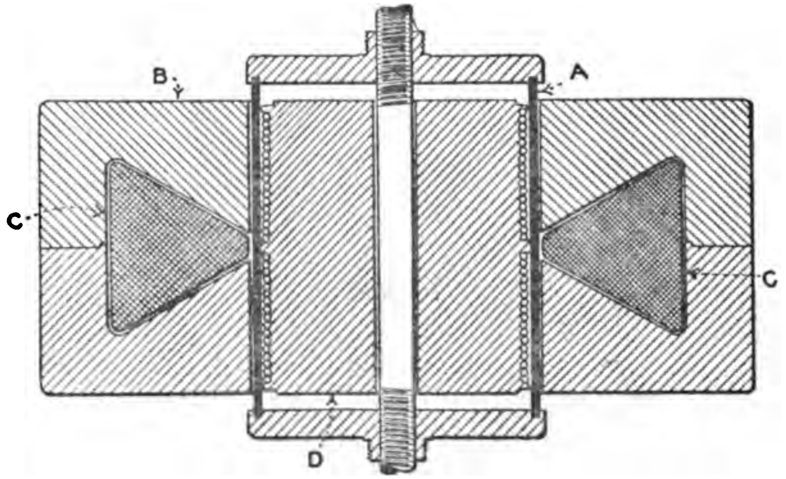


FIG. 2.

Around the armature is wound a fixed winding, which we shall call the armature winding, and which is reversed in direction so that one half of the winding is clockwise and the other counter-clockwise. When an alternating current is passed through this armature winding, it induces another alternating current in the copper tube, the actual value of which is approximately ten thousand ampères. This, of course, is due to the low resistance of the copper tube. This current of ten thousand ampères flowing through the copper tube, and the copper tube lying in a field of more than fifteen thousand lines per square centimeter, electric forces are brought into existence very much more intense than those which occur in the ordinary dynamo or motor; and the copper tube weighing only a few pounds, is driven to and fro with a force of more than two tons, approximately one thousand times per second.

Only by this construction has it been found possible to obtain the enormous force and rapidity necessary to compress the water and to overcome the inertia of the moving parts of the mechanism.

In order to apply this force to the work of compression, the copper tube is attached to solid discs of steel, which in turn are attached to a steel diaphragm one inch thick, or to the side of the ship. In practice, the tube is provided with lugs, and is held between two discs drawn together on the tube by a one-inch vanadium-steel rod and a right-and-left-handed screw thread.

The power used to operate this oscillator is an alternating current of five hundred cycles per second. By speeding up or slowing down the generator, it is possible to obtain any desired note in the oscillator. The frequency to be used in practice should be the frequency which is required to give resonance in the diaphragm.

Telegraphing is accomplished by means of an ordinary telegraph key, placed in the main circuit.

It is surprising to know that with the large current which this key interrupts there is very little sparking at the contacts. This is particularly surprising when one remembers that an alternating current of 500 cycles is being used. It is also surprising to note that laminated iron has not been used in the construction of the apparatus. The secret of this rather unusual behavior lies in the fact that the armature has substantially no self-induction, and no eddy currents are generated in the apparatus. This is because the copper tube forms, as will be seen, the short circuiting secondary of a transformer, of which the armature winding is the primary. This eliminates the self-induction of the armature winding. In addition, the upper and lower portions of the winding are wound in opposite directions, and, therefore, there is no mutual induction between the field coil circuit and the armature circuit. With this construction, the amount of magnetic leakage in the armature circuit is very small, only a trifle more than if the armature core were of wood; and as there is no alternating magnetic flux in the iron, there are no eddy currents.

As regards the capacity in kilowatts of this apparatus, it is quite large. The armature being wound in grooves in the armature core, so as to withstand the mechanical forces acting upon it, is well cooled. The copper tube has no insulation to be affected, and on account of its large cooling surface and high permissible temperature of operation, can carry very high currents without injury.

Operating at a frequency of five hundred per second, there is no difficulty in obtaining 35 kw. in mechanical power delivered to the water, and an efficiency of over 90 per cent, this efficiency being, I think, worthy of note, in view of the fact that the motor is a reciprocating one, and is operated by alternating currents of such high frequency. Attention may also be called to the simple construction of the motor, since for most purposes the armature winding will consist of a single layer of square copper strip, embedded in grooves in the iron, and the copper tube, the only movable element, is entirely uninsulated.

With large amplitude of stroke, much more power may be taken out, and at a piston speed of one thousand feet per second, the output of these oscillators will be in the neighborhood of 1000 kw.

As the ordinary telephone receiver gives an audible note at a frequency of one thousand per second, with approximately one-three-hundredth of a volt, it will be seen that an audible note will be produced if the oscillator diaphragm be set in vibration through a distance of only one ten-thousandth of one-millionth of an inch, or approximately one ten-billionth of an inch.

Now, despite the fact that the diaphragm is of steel, one inch thick, and weighs more than one hundred pounds, even weak sounds are able to produce this displacement. You will find that even the faintest whisper made in the neighborhood of the diaphragm can be heard in the telephone receiver connected to the armature winding. In fact, the tests which have been made show that the oscillator, acting as a telephone transmitter, is, for weak sounds, approximately ten times as sensitive as the best microphones that have been constructed. The same oscillator is therefore used for sending and for receiving, a switch being thrown in one direction when it is desired to telegraph under water, and thrown the other way when it is desired to listen-in.

In addition to telegraphing and receiving messages, there are many other uses to which the oscillator can be put; for example, it can be used for telephoning under water. If the oscillator is connected to an ordinary telephone transmitter and a few dry cells, and someone talks in the transmitter, the oscillatory currents produced by the sound of the voice will set the copper tube in the oscillator in motion, driving the copper tube backwards and forwards an average of eight hundred times a second, also bending an iron plate, three-quarters of an inch thick, which forms the side of the ship, and compressing the water. Even with these minute telephonic currents (the transmitter is one of the ordinary commercial type) the motion is not, as might be expected, imperceptible, for if the finger be laid on the iron plate, it can be felt in vibration.

The compressional waves in the water travel along to the other oscillator (which represents the shore station), bend the one inch steel diaphragm, and set the copper tube attached to the diaphragm in motion, thereby generating electric currents in the armature winding; and, if some one be listening-in on the telephone receiver at the shore station, he will hear the words which are being spoken into the telephone transmitter on board the tug.

As regards the distance through which it is possible to telephone under water, the apparatus connected under these rather unfavorable conditions, using only six dry cells and an ordinary telephone transmitter, has actually operated over a distance of more than one-half mile, the speech being received on an overboard microphone, which had been previously lowered into the water.

It is therefore certain that with more suitable power, and using another oscillator as receiver, distances of at least five miles can be reached, and doubtless considerably greater when the apparatus is perfected. Long distances are not however necessary, as even with a distance of seven miles, it will be readily understood that this method of under-water telephoning will be of great use as a means of communicating between the shore and the tug.

As might be expected, the oscillator is capable of acting
a very efficient loud-speaking telephone, especially if a
ible mouthpiece is attached to it.

There follow tabulated data which give the results of several authenticated tests conducted on various ships by the Submarine Signal Company. The remarks are self-explanatory in most instances. The notation "P. H. B. B." refers to Peaked Hill Bell Buoy. The first table gives the results that have been obtained in tests between surface ships. The second table gives the results of tests between submarine boats, and in some instances between submarine boats and a surface boat. In all of these tests, where it is stated that messages were transmitted, the rate is twenty-five words per minute. The sketches shown in the submarine tests under the head of "Remarks" indicate the relative positions of the two boats during the test; thus, under date of "7/10/14," the two boats shown at an angle of 60° to each other represent the courses of the two vessels during the tests. In some of these tests, mention is made of bell buoys and light-houses. Where a bell is mentioned, the bell used is one of those designed by the Submarine Signal Company for use as aids to navigation. Where an oscillator is spoken of, it refers to the Fessenden oscillator previously described. Where mention is made of an overboard oscillator, it refers to an oscillator which is suspended overboard by means of cable and chains; therefore, the overboard oscillator is not an integral part of the ship, but is a temporary installation used for testing only. It seems that when favorably located on the ship, much better results should be obtained when the oscillator is permanently installed, as this method would probably eliminate a great many water noises. In some of the tests with submarine boats, mention is made of two distances; one of these represents the distance to which messages were transmitted and the other to which signals were transmitted. Where distances are given as those to which messages were sent, it is to be understood that the messages were received without difficulty up to those distances.

From the data given, it can be seen that submarine signalling by means of Morse code or telephone is an accomplished fact, and therefore available for military use. From the distances over which actual messages have been sent and received, it can be observed that the installation, even in its present state of development, should have a sufficient range to give excellent results in shore-tug signalling.

## OSCILLATOR TESTS

### SURFACE SHIPS

| DATE | RECEIVING | SENDING | DISTANCE (naut. miles) | SPEED (knots) | DRAFT (ft. and in.) | REMARKS |
|---|---|---|---|---|---|---|
| 4/4/13 | Launch | *Delaware* | 8 | . . | . . | Received with overboard oscillator. Oscillator attached to skin. |
| 5/15/13 | *Wyoming* | *Delaware* | 2¼ | ? | . . | Good direction and clear. Did not try farther. |
| 5/15/13 | *Wyoming* | *Ambrose* | 8 | 10 | . . | . . . . |
| 1/8/14 | Overboard rec. on *Neponset* | *Susie D.* | 31 | 0 | . . | Heard P. H. B. B. 23 miles. L. S. (Boston) bell faded out at 16 miles. Could hear dots and dashes, though much foreign noise. At 24 and 31 miles the L.S. was between *Susie* and us. |
| 4/8/14 | *Devereux* | Boston L.-S. | 3½ | 11 | 4′ 6″ | *Devereux* going out could not hear further on account channel. Direction O. K. |

## OSCILLATOR TESTS

### SURFACE SHIPS

| DATE | RECEIVING | SENDING | DISTANCE (naut. miles) | SPEED (knots) | DRAFT (ft. and in.) | REMARKS |
|---|---|---|---|---|---|---|
| 4/8/14 | *Devereux* | Peaked Hill B. B. | 4 | 11 | 4′ 6″ | Microphones heard only 2 miles. Direction to 1 point. |
| 4/9/14 | *Devereux* | Barnegat | 4 | 11 | 4′ 6″ | B. B. dead ahead. Direction to 1 point. |
| 4/12/14 | *Devereux* | Barnegat | 13 | 8.5 | 17 | Nearest approach to bell 10 miles. |
| 4/13/14 | *Neponset* | *Devereux* | 11.3 | 8.5 | 17 | *Devereux* coming bow on. Neponset used overboard oscillator. |
| 4/23/14 | *Devereux* | Barnegat | 12 | .. | .. | Microphones picked up bell 25 minutes later. Direction O. K. |
| 4/23/14 | *Neponset* | *Devereux* | 14 | .. | .. | Neponset used overboard oscillator. *Devereux* head on. |

## OSCILLATOR TESTS

### SURFACE SHIPS

| DATE | RECEIVING | SENDING | DISTANCE (naut. miles) | SPEED (knots) | DRAFT (ft. and in.) | REMARKS |
|---|---|---|---|---|---|---|
| 4/29/14 | *Devereux* | Barnegat | 4.5 | 11 | 4′ 6″ | Microphones heard only 2 miles. Fog. Sound screens down. Direction not so good. |
| 5/1/14 | *Devereux* | Barnegat | 11 | 8.5 | 17′ 6″ | . . . . |
| 5/2/14 | *Leader* | *Devereux* | 20 | 8.5 | 17 | *Leader* used overboard oscillator. *Devereux* head on. |
| 6/2/14 | *Devereux* | Barnegat | 5 | 8.5 | 17 | 2 points on port bow. |
| 6/3/14 | *Neponset* | *Devereux* | 18.7 | 8.5 | 17 | . . . . |
| 6/3/14 | *Neponset* | *Susie D.* | 10 | . . | . . | 2 overboard oscillator test for newspaper men. |
| 6/6/14 | *Devereux* | P. H. B. B. | 4 | 11 | 4′ 6″ | B. B. dead ahead. |
| 6/7/14 | *Devereux* | Barnegat | 3.6 | 11 | 4′ 6″ | Bell buoy dead ahead. |
| 6/11/14 | *Neponset* | *Devereux* | 20 | 8.5 | 18.6 | 3 points to port. |

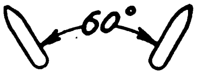
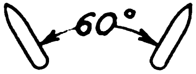
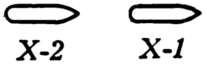
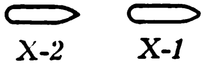
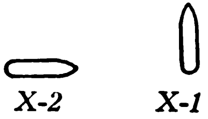
## OSCILLATOR TESTS

### SURFACE SHIPS

| DATE | RECEIVING | SENDING | DISTANCE (naut. miles) | SPEED (knots) | DRAFT (ft. and in.) | REMARKS |
|---|---|---|---|---|---|---|
| 6/12/14 | *Devereux* | Peaked Hill B. B. | 4 | 8.5 | 18.6 | 1 point to port. Oscillator good as soon as corner of cape was passed. |
| 8/27/14 | *Wyoming* | *Delaware* | 3 | . . | . . | . . . . |
| 9/2/14 | *Wyoming* | *Delaware* | 6 | 10 ? | . . | Messages 4 miles; signals 6 miles. |
| 11/7/14 | *Utah* and *Arkansas* | *Utah* and *Arkansas* | 10 | . . | . . | Did not try farther. *Arkansas* had overboard oscillator. *Utah* had one in skin and one in tank. |

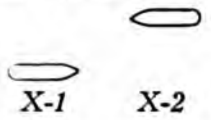
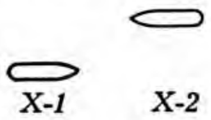
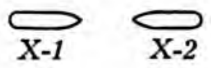
## OSCILLATOR TESTS

### SUBMARINE BOATS

| DATE | RECEIVING | SENDING | DISTANCE (naut. miles) | SPEED (knots) | DRAFT (ft. and in.) | REMARKS |
|---|---|---|---|---|---|---|
| 7/13/14 | *X-1* | *X-2* | 6½<br>10 | Submerged 7½ | Submerged 17′ | Messages to 6½ miles. Letters to 10 miles.  |
| 7/13/14 | *X-2* | *X-1* | 7<br>11 | Submerged 7½ | Submerged 17′ | Signals to 11 miles, as far as tried.  |
| 7/13/14 | *X-1* | *X-2* | 2½ | *X-1* 7½<br>*X-2* Stop | Submerged 17′ | In this and two following tests, sheet iron fair waters were secured to forward side of oscillator.  |
| 7/13/14 | *X-2* | *X-1* | 3 | *X-1* 7½<br>*X-2* Stop | Submerged 17′ |  |
| 7/13/14 | *X-1*<br>*X-2* | *X-1*<br>*X-2* | 3¾ | *X-1* 7½<br>*X-2* Stop | | Messages exchanged very well. Did not try farther.  |

## OSCILLATOR TESTS

### SUBMARINE BOATS

| DATE | RECEIVING | SENDING | DISTANCE (naut. miles) | SPEED (knots) | DRAFT (ft. and in.) | REMARKS |
|---|---|---|---|---|---|---|
| 7/13/14 | X-*1* | X-2 | 3 | Both 7½ | | Messages to 3 miles. Letters to 7½ miles.<br> |
| 7/13/14 | X-2 | X-*1* | 5½<br>10 | Both 7½ | | Messages to five miles. Letters to 10 miles.<br> |
| 7/13/14 | X-2 | X-*1* | 6 | Both 7½ | |  |

# THE ANGULAR-TRAVEL RULE

By 2nd Lieutenant FRED M. GREEN, Coast Artillery Corps

## OBJECT

The *angular-travel rule* is a device for determining the angular rate of travel of a target with respect to a seacoast gun-battery. It takes the place of the tally dials of the plotting board. The following advantages are claimed for it: greater speed in determining the angular travel (giving deflections more promptly after the bell); greater accuracy in determining the same; and a reduction of the duties of the plotter (with consequent increase of accuracy in plotting).

## DISADVANTAGES OF TALLY DIALS

Since the introduction of plotting the set-forward point on gun plotting boards, various companies have used different methods for finding the angular travel. The general practice has been to use the tally dials, and by means of them to measure either—

1. The angular difference of two observed points; or
2. The angular difference of two set-forward points.

The former method possesses greater precision, but involves so many movements* that the plotter becomes hurried and accuracy suffers. Moreover, a careful performance of these duties leaves him insufficient time to study the track and estimate the course the target will probably follow.

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* These may be briefly noted as follows:

1. Plotting the observed point, and clearing away the arm or arms.
2. Predicting the set-forward point, by whatever means employed at the battery.
3. Placing the targ on the set-forward point, bringing up the gun arm, and reading the range.
4. Placing the targ on the last observed point, bringing up the gun arm, waiting for the tally-dial man to read his travel and reset his tally dials.

Confusion sometimes results as to which the last observed point really is, especially if the target doubles on its track; though, of course, operation 4 may be done before 2 and 3, but in that case the number of motions is still further increased, and the range arrives at the emplacement very late.

The second method involves fewer movements, and for a uniform course gives good results. Any irregularity in the speed of the target, however, or even the irregularity resulting from the instrumental errors of a D. P. F. on a low site, will result in most abnormal values of travel, and hence give erratic deflections.*

A second disadvantage of this method is that three observations are required to determine the first deflection of a track—a serious delay in changing targets or in opening fire on a target suddenly discovered. Despite its inherent defects, this method is nevertheless sometimes used, for the reason that the first method requires such skill and speed on the part of the plotter.

Both methods alike have these disadvantages:

1. The attention of the plotter is distracted by the movements of the tally-dial man, by whose speed in reading and setting the dials he must be governed. Several valuable seconds of the plotter's time are wasted in each observing interval—seconds that might well be spent in "sketching in" his track.

2. Material errors in travel are possible: backlash in the gun-arm subdial indicator, or inaccuracies in setting the dials, or, most probable of all, a failure to hold the targ exactly on the correct point while holding the gun-arm against its edge, all tend toward errors in travel; and these errors, while immaterial in the case of a target towed on a regular course at a low and uniform speed, may become vital in the case of a warship moving at a high and irregular speed over a varying course. In short, in either system, the travel is obtained by a slow and round-about method, whose accuracy is predicated on the correctness of a series of successive steps.

It is therefore evident that a more rapid and more direct method of determination is desirable, and it is as a possible solution of the problem that the *angular-travel rule* is submitted.

## DESCRIPTION

The *angular-travel rule* is a slide rule, with three uniform scales as shown.† With ordinary rough carpentering and pencil subdivisions, a scale of one decimeter to one degree is recommended. With more accurate construction, a smaller scale may be adopted, resulting in a more compact instrument. Scales 1 and 2 have fourteen divisions of one degree each, which are numbered from left to right as follows: 8, 9, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, and 1. Smaller graduations of 0°.10 and 0°.05 are provided, and interpolation by eye permits satisfactory setting to 0°.01. A sliding index (at the top) assists in aligning any two given points on scales 1 and 2. Scale 3 is graduated from right to left from 12 to 18—15 being the normal at the center of the board. An arrow on the slide points to 15 when the slide is at the center and scales 1 and 2 in coincidence. The figures on scale 3 are *inverted*, so as to be read from the top of the board.

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* A mathematical example of this is given in appendix "A." In this method, any given error multiplies itself.

† Dimensions which have proved satisfactory are given in Appendix "B."

To operate the board, the azimuth of the target from the battery must be determined every thirty seconds. In batteries which have either base-end station at or near the emplacement, this data is repeated aloud by an arm-setter in the plotting room. For batteries where neither base-end is near the battery, the data will be taken from the battery commander's instrument (or from a spare azimuth instrument mounted in a crow's nest) and phoned directly to the operator of this rule.

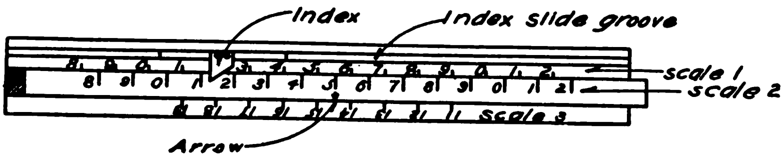

Fig. 1.
The angular-travel rule.

On receipt of the first observation, the operator sets the sliding index to read the *last three figures** of the azimuth on scale 1.

On receipt of the second observation, the operator moves the slide until the last three figures of the second azimuth (on scale 2) are opposite the edge of the index. The arrow on the slide now points to the angular travel reference number, which is read directly by the operator of the deflection board, who sits opposite.

The index is now reset to read the latest azimuth on scale 1. (This azimuth need not be carried in the head, as it can be read from scale 2.) A new observation is now awaited, and the cycle repeated.

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* Thus, azimuths of 3°.17 – 13°.17 – 243°.17 are set exactly alike.

The rule is placed on the same table with the deflection board, so that the operators face each other.

### ADVANTAGES

For this arrangement the following advantages are claimed:

1. Owing to the directness of the method, several possible sources of error are eliminated.
2. The deflection board operator receives his travel within five seconds after the bell, and can send a much "fresher" deflection. In other words, the deflection reaches the guns at least fifteen seconds sooner than is the case when using the tally dials.
3. The plotter has one less duty, and can devote more time to the others. In the case of a hostile target following an irregular course, this added time is of especial value, as it enables him to judge better which way to throw his set-forward points in view of the previous track.
4. Less skill and training are required to operate this rule than to operate the tally dials at the speed required by the present system of plotting. Less speed is required of the plotter. The problem of training militia range sections, and supernumerary range sections for regular companies, is thereby simplified.
5. Delays on the operator's part cannot hinder the plotter.
6. Identification of the last observed point after predicting the set-forward point is no longer necessary.
7. One man is removed from the plotting board. The work of the plotter and arm-setter will be improved by the reduction in noise and movement around the board, and by their release from the necessity of coordinating their movements with those of a third party. The calling aloud of the angular travel is rendered unnecessary.
8. Erratic values of travel are at once detected by a sudden movement of the slide. So also, if any observation be lost, the arrow will still stand at the last travel determined, and, if the course be fairly even, the missing deflection may be approximated. On the following observaton the slide may be set as usual and the distance of the arrow from normal be

bisected by eye, giving the mean travel during the last two observing intervals. This cannot be done on the travel scale of the deflection board, as its divisions are not equicrescent.

9. In changing targets, a deflection can be sent to the guns before the first set-forward range is obtained.

## Application of the Angular-Travel Rule to Intermediate Batteries Not Equipped with Horizontal Base Lines

By means of the angular-travel rule, a greatly simplified system may be used in the plotting rooms of those 5-inch and 6-inch batteries which are to be equipped with a single depression position-finder or a self-contained horizontal base instrument at the battery.

During the maneuvers in the Coast Defenses of Long Island Sound in 1913, many excellent opportunities for effective fire were lost, due to the delay caused by predictions. "By the time we got a curve on the time-range board, the destroyers were gone," was a frequent comment.* Analysis shows that at least eighty seconds of time must elapse after the first observation before a shot can be fired, and in this time a 30-knot destroyer will travel 1350 yards—over three-quarters of a mile.

The following scheme is designed to:

1. Expedite the opening of fire.
2. Simplify the drill of the range section.
3. Reduce the cost of equipping these batteries.

The most bulky, expensive, and complicated piece of apparatus in the plotting room is the plotting board. Its functions are:

1. To relocate for directing-point ranges.
2. To relocate for directing-point azimuths.
3. To obtain the rate of travel in range.
4. To obtain the rate of travel in azimuth.

Consideration of these functions shows that:

1. Relocation for ranges could be eliminated by making the self-contained instrument the directing-point for the battery.

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* See also report of C. O., N. A. C. A. Dist., *Artillery Notes No. 37*, page 55, par. 32.

2. Relocation for azimuth is needless at an intermediate battery. Case III is not adapted for use on destroyers, owing to their high speed and variable course, and because of the slow rate of fire which indirect laying requires.
3. Range correction for travel could be applied on the Pratt Range Board by the use of a string, as formerly.
4. Angular travel can be determined by the angular-travel rule.

The plotting board could thus be eliminated at intermediate batteries not equipped with horizontal base lines. Ranges are then transmitted directly from the reader to Number 4 (C. A. D. R., 1914, par. 76), who applies his correction and announces the corrected range to Number 6. The angular-travel rule operator receives his azimuths by a headset bridged with that worn by Number 4. Number 5 calls his deflections to Number 6, who is charged with transmitting both range and deflection to the guns.

By this system, corrected ranges and azimuths arrive at the guns forty seconds after the first observation. As noted above, eighty seconds time is required when using the plotting board. The importance of this saving of time requires no comment.

In view of the many intermediate batteries which would have to be manned by Coast Artillery Militia in time of war, the simplicity of the system proposed is an advantage. No arm-setters, no plotter, and no assistant plotter are needed, and the one additional man required can be trained more readily than any of the above.

The only apparatus required is a range board, a deflection board, an angular-travel rule, and a wind component indicator.

## APPENDIX A

Fig. 2 illustrates the track of a target. For clearness, a scale of 100 yards to the inch is used. The travel during any interval (such as A) leads to the prediction of the set-forward point marked with the same letter. For the sake of a definite computation, a range of 9000 yards and an average speed of 100 yards during an observing interval (about 6.8 m.p.h.) are assumed.

To simulate irregularities in the track, the third and sixth points are assumed to be in error by 25 yards—an error not in excess of those frequently found, especially in the case of batteries equipped with a D. P. F. only.

The irregularities of the set-forward points are found to be out of all proportion to the errors which cause them. The error of 25 yards in the position of the third and sixth points leads to the following intervals between set-forward points, viz.: 38 yards, 201 yards, 61 yards, 162 yards, zero (two set-forward points being coincident), and 138 yards. Discussion of the effect on angular travel is superfluous.

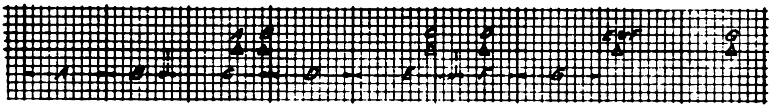


FIG. 2. 1635

## APPENDIX B

### DIMENSIONS AND SCALES

The model of this rule is five feet two and one-half inches in length. The fourteen divisions of one decimeter each, occupy four feet seven inches, leaving about three and one-half inches at each end ungraduated. The other dimensions of this rule are shown in Fig. 3.

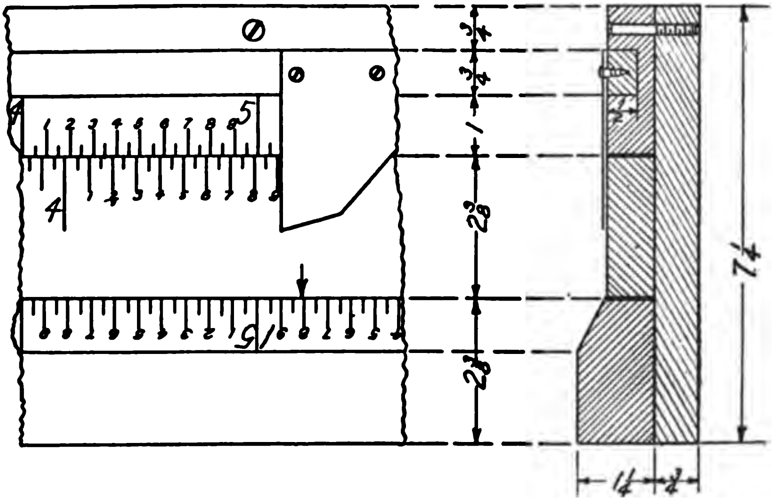


FIG. 3. 1636

A scale of five centimeters to a degree is large enough to be clearly and accurately read. A rule made to this scale, and graduated to the very end, will be two feet three and one half inches in length. This size is well adapted for use in small plotting rooms.

The bevel on scale 3 has been found desirable, as it assists the operator of the deflection board to read his travel. Experience shows that when the deflection board operator reads his own travel, deflections are obtained more rapidly and with less chance of error than by calling the travel reference number aloud.

# A DEVICE FOR CORRECTING FOR PIT DISPLACEMENT IN MORTAR BATTERIES

By 1st Lieutenant JOHN H. PIRIE, Coast Artillery Corps

This device is intended primarily for use whenever mortar pits are to be fired alternately. When battery salvos are fired, it will require rapid work on the part of the operators of the elevation and deflection boards, unless one each of those boards is supplied for each pit.

The device is designed to make both the range and the deflection corrections that are necessary because of the displacement of the pit from the directing point of the battery.

The device consists of a slide to be placed on the mortar arm of either the old or the 360-degree mortar plotting board.

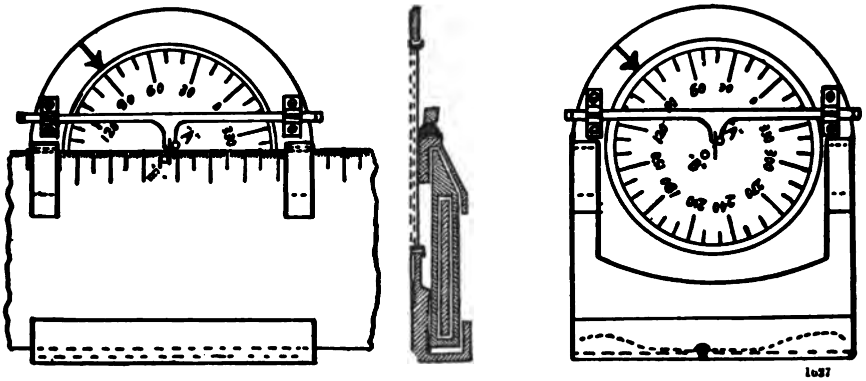
The slide carries a ring of metal into which is fitted a disc of celluloid so that the exact center of the disc is at all times under the graduated edge of the arm. The disc is mounted as shown, so that it can be turned within the outer ring in such manner as to bring any number opposite the pointer on the outer ring.

The outer edge of the disc is graduated to ten degrees, and each thirty-degree mark is numbered, in a counter-clockwise direction, from 0 to 330 degrees inclusive.

In line with the zero of the degree circle are two small holes punched in the celluloid, one on each side of the center of the disc. These holes are placed a distance apart corresponding to the distance between the centers of the pits of the battery to the scale of the board.

There is a pointer which can be moved in range only and which will indicate the exact range of the hole over which it is placed.

The position of the indicator line on the outer circle will depend upon the azimuths of the base line and the line joining the centers of the pits. The simplest way to determine the position for this line is to place the slide on the mortar arm, and to place the arm in a position perpendicular to the line joining the pits. Place the line between the holes in the disc parallel to the line between the pits; *i.e.*, place the holes representing the pits in their proper relation to the azimuth of the base line on the board. Draw the indicator line on the outer ring opposite the number on the disc corresponding to the azimuth at which the mortar arm is set. If the indicator line falls under the arm where it could not be seen, the letters "A" and "B" indicating the holes for "A" and "B" pits should be interchanged, and procedure had as before. The line will now fall out from under the arm.



To operate, the plotter keeps the number on the disc corresponding to the approximate azimuth to the target set opposite the indicator line and sets the pointer over the pit next to fire. After he plots the position of the set-forward point, the plotter brings the proper pit directly over the point, and the correct range and azimuth for the pit are read directly from the board. If both pits are to fire, the plotter would bring the pits in succession over the same set-forward point and obtain separate data for each pit without any change of settings on the device.

This device is as applicable to the new as to the old mortar plotting board.

# VESSEL TRACKING DURING THE INDOOR PERIOD

By Captain CHARLES C. BURT, Coast Artillery Corps

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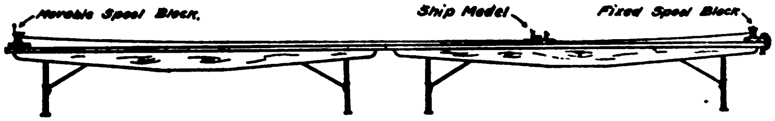
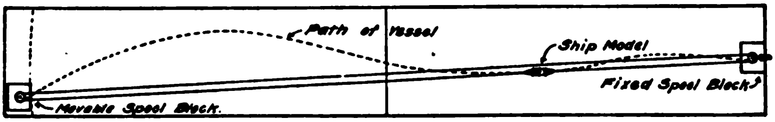
The following sketches and description of a vessel tracking device for use in indoor instruction, which have been used very successfully in the 4th Co., Coast Artillery Corps, are submitted in the belief that the scheme may be of interest to the service.

Indoor instruction in the duties of the plotting room is held in the dining room of the barracks. Two mess tables are placed end to end, as shown, at one end of the dining room, either parallel to the wall or at any desired angle. Two large spools on spindles in wooden blocks about 6″ x 6″ x ½″ are used, one block clamped to the table and the other movable, as shown. The spool on the movable block has a small nail in it to serve as a handle. A piece of stout linen thread of proper length is given two turns around each spool and the ends made fast to either end of a ship model, such as is used the Coast Artillery War Game. An operator, sitting at the end of the table, holds the movable spool block with one hand so that the thread is sufficiently taut, and turns the spool with the other. The model then moves along the tables, according to the direction in which the spool is turned. By manipulating



Elevation

1638



Plan

1639

the block back and forth across the table, a curved path, such as shown in the plan, is obtained.

At the other end of the dining room, separated as far as possible, are two azimuth instruments, one representing the B′ observing instrument, the other the B″. The arms on the plotting board are arbitrarily placed at any desired intersection on the board, either for extreme, mid, or short range, and to the right or left side of the board, according to the position of the model. Assuming that the model is placed up close to the fixed spool block, then the plotting board arms would be laid to an intersection in the right quadrant of the board. With the model stationary, the azimuth instruments are oriented on the designated observing point on the model, each instrument having the same azimuth reading as its corresponding arm on the board. It will be seen that, by changing the position of the tables, and position of the movable spool block, and the speed of the model, all kinds of combinations of range and azimuth changes can be effected.

The scheme is the result of a combination of ideas of 2nd Lieut. R. E. Haines', C. A. C., of Sergeant Issac M. Palmer's, 4th Co., C. A. C., and of mine.

# AZIMUTH AND ELEVATION CHECKING DEVICE FOR MORTARS

By 2nd Lieutenant GEORGE F. HUMBERT, Coast Artillery Corps*

The following is a simple and efficient method of checking any error that may creep into data as posted, due to faulty observation, reading, plotting, or transmission. Changes of zone and projectile make no difference in spacing of chalk marks.

The construction of the device is simple and can be accomplished by any company mechanic as follows: A triangular block of wood, with dimensions as desired, is painted black.

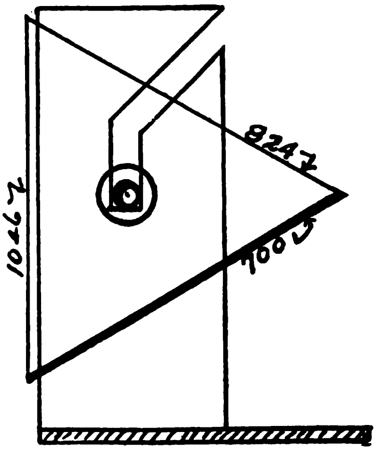


Fig. 1.
End view.

On each one of the faces of the block a drift scale is painted in white: on one face, the drift scale for the 700 pound projectile; on the next, that for the 824 pound projectile; and on the third, that for the 1046 pound projectile. The only precaution necessary is that the elevation corresponding to the same drift in the three scales, shall be on a continuous line around the three faces of the block. A wire nail is driven part way into each end of the block. A bracket is constructed, the block placed in the bracket, and the bracket secured to the racer by means of one of the azimuth-index-box cover screws. The device is then ready for use.

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* The author acknowledges indebtedness for assistance in the construction of the device to Mechanic Martin, 105th Company, Coast Artillery Corps.

The operation is as follows: Say the target is in the seventh zone (1046 pound projectile): turn the block so the 1046 scale is exposed; data are posted; the azimuth setter sets the azimuth, and then, opposite the elevation on the block, draws a short chalk mark on the floor-plate. As successive data are posted, providing no errors have crept in, equally spaced chalk marks are obtained. When the target arrives in the eighth zone, merely shift the block to the 824 face; in the ninth zone, to 700 lb. face. The changes of zone and

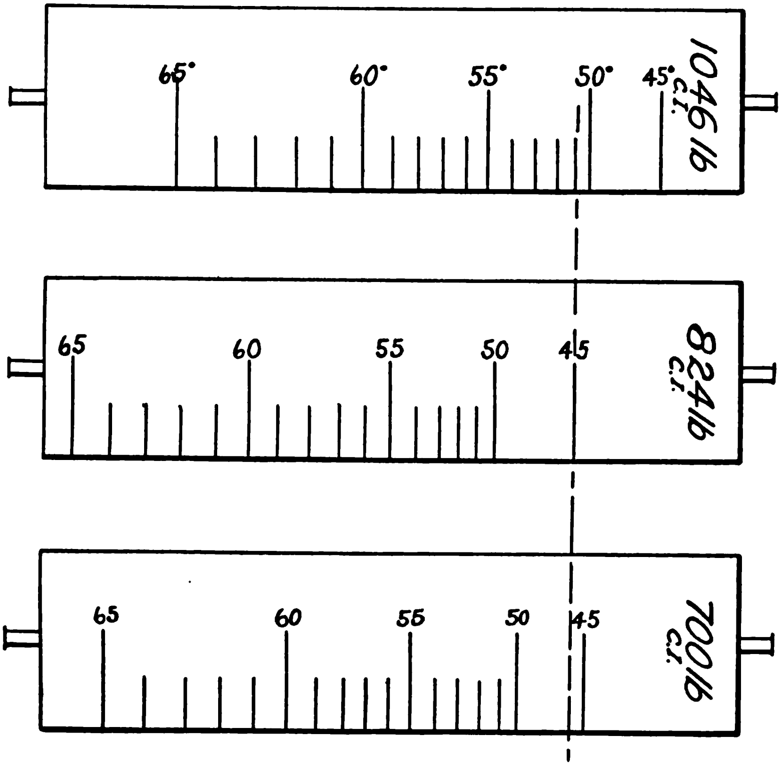

FIG. 2.
Drift Scales.

projectile will make no difference in the spacing of the chalk marks, as long as no errors have been made in the data chain. Any error will immediately show by an unequal spacing of the chalk marks.

The emplacement officer checks the data marks each time the piece is reported ready, and his report as to "ready" or "wrong azimuth" is based on the spacing of the chalk marks.

# PROFESSIONAL NOTES

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## THE ART OF REPELLING LANDINGS[*]

By Colonel C. E. Callwell, C. B.

In addressing you to-night, I feel like a fool rushing in where angels fear to tread. As far as I am aware, the tactics called for in repelling landings have not been touched by anybody of recent years, and they certainly have not been touched in "Combined Training" or in "Field Service Regulations." Practically the most recent precedent of an opposed disembarkation is Abercromby's landing in Aboukir Bay, in the days of cannon balls and Brown Bess, so that I am, as it were, plunging into the unknown.

I propose only to consider the question how an enemy landing on an open beach in this country ought to be met, that is to say, the case where a hostile armada arrives, anchors off the shore, and tries to get troops to the land in open boats, the operation being probably covered by gun-fire from some sort of an accompanying fleet. And, as this gun-fire of the enemy's is likely to prove an important factor in deciding the issue, I will begin by saying a word as to it.

### Gun-Fire from Warships Covering a Landing

You must remember that sailormen in general do not know much about the use of shrapnel, that they are not used to firing at very indistinct objects scattered about on dry land, and that they have no experience of tossing up shrapnel just over the heads of their own pals, with the chance of hitting those pals in the back. Covering a landing with gun-fire from on board ship cannot, in the nature of things, be a particularly easy job to carry out effectually; but navies appear never to practise it, and, if called upon to do it, they may make a mess of it. I mention this because the troops on land should on this account try to puzzle the ships' gunners as much as possible, and should endeavor to give those gunners just the kind of task that they will botch.

It is easy to picture to oneself the sort of objective that sailors would choose for their guns. A good upstanding bluff with the defenders perched on the summit and sheltering themselves (shall we say?) behind a conspicuous hedge—that is the kind of target that the naval gunner will soon get the range of, and that he will not be afraid of deluging with shrapnel even when the boats are nearing the shore. But when it is a case of khaki-clad infantry distributed about on low-lying, hummocky, undulating ground of the type that one associates with seaside golf, where there are bents and sand-patches and scrub and where the background is afar off, neither the layer nor the officer directing the fire will find the game so easy. Common shell against that class of mark can at the best only have somewhat disappointing results, and the employment of shrapnel under these circumstances in reality calls for the trained expert. Nor should it be forgotten that in virtue of its wide cone of dispersion, shrapnel from monster ordnance is an unhandy projectile to fire over the heads of your own troops, if you are not an old hand at that sort of performance.

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[*] urnished for publication through the courtesy of the War College Division of the Staff.

From this brief consideration of the problem from the naval gunner's point of view, most valuable lessons can be deduced on the subject of the disposition of a body of troops drawn up to oppose the landing of a force when the operation is being covered by the artillery of warships. Commanding sites are *bad* because they help board-ship gun-layers and fire-directors to see what they are doing. Anything that stands out from its surroundings like a hedge or a wall or a coppice is *bad* because it offers a well-defined target to the enemy. On the other hand, ground that is little raised above sea-level and that approaches close to the water's edge is best, assuming, of course, that there is cover and that it is somewhat broken; and troops posted on such sites can safely reckon on being relieved from the annoyance of hostile shrapnel fire some little time before the bows of the enemy's boats touch the beach.

### THE IMPORTANCE OF COMMAND TO THE DEFENDING SIDE

I have shown that, looked at from the point of view of protection against the gun-fire of a covering fleet, an elevated position is a bad one for troops opposing a landing. But immunity against loss is not the only matter to be considered by the defending force. The *raison d'etre* of that force is to deny passage to the enemy from his transports to the beach, or at the worst to cause as much damage as possible in the adversary's ranks before the landing parties manage to set foot on shore; and it so happens that from this point of view command is decidedly advantageous—and for this reason.

The infantry soldier suffers under one most predjudical disability on the ordinary battlefield—he does not know what has become of his bullets. He does not, as a rule, see where they strike, and he generally cannot tell whether, assuming that he is holding his rifle steady and that he is aiming correctly, they have hit what he is firing at or even whether they have gone reasonably close to the mark. But when he comes to firing at an object in the water it becomes quite a different story, whether that object be a boat or whether it be a bottle. The splash on the water tells him where his bullet has gone to, and he can observe the effects of his fire just as the coast-defense gunner does. But if the infantryman is down by the water's edge, and if his target is, say, 1000 yards out to sea, although he can see the bullet's splash and can tell what sort of shooting he is making as regards direction, he cannot tell with accuracy how he is getting on as regards range. Moreover, supposing that he is firing at a large object like a boat and that his bullet passes over the top of the boat, he cannot see the splash at all. As a matter of fact it is the case that, as the distance increases of the object aimed at out at sea, the requisite height to properly overlook it grows in an expanding ratio. For instance, supposing that a rifleman whose eye is 10 feet above sea-level can tell pretty well what shooting he is making at a barrel floating, say, 200 yards out, his eye will have to be more than 20 feet above sea-level to tell equally well what he is doing when the barrel is 400 yards out. It is a question of convexity and of angles, and a mathematical formula no doubt exists or could be devised for the benefit of those who take their pleasure in such things. Practically, it would work out something like this—10 feet for 200 yards, 30 feet for 400 yards, 100 feet for 1000 yards, 200 feet for 1500 yards. Now, what lesson do we learn from all this? Is it not, that the infantryman ought to be raised up well above the sea-level, so that he shall be able to get full benefit out of the fact that the splash on the water informs him of the results of his shooting almost as well as the marker does at the butts.

The benefits arising from a commanding position when confronting a hostile landing of course apply to the artillery of the defense and to machine guns as well as to the infantry, and they also apply to the cyclists and to the mounted troops with their rifles.

It must be remembered that it by no means necessarily follows that a hostile landing on our coast will be covered by the gun-fire of war-ships. The enemy may make a dash for the shore, chancing losses, without naval support of any kind. Such a situation is indeed very likely to occur where the landing is merely intended as a feint, or where it is undertaken in conjunction with others for the purpose of gaining a footing somewhere preparatory to a disembarkation on a larger scale near at hand. Under such circumstances the defenders can dispose themselves on conspicuous bluffs without any fear of being crushed by shell fire, and in these conditions, *cæteris paribus*, they should select high ground in preference to low ground for their line of battle, always provided that in doing so they do not unduly sacrifice range.

The ideal position under these special circumstances in fact may be taken to be the crest of a cliff overhanging the enemy's intended landing place. On such a spot the defenders get the full benefit of command without being retired from the water's edge.

### THE TAKING UP OF A DEFENSIVE LINE

We are now in a position to review a few of the main points which ought to be taken into account when settling upon the defensive line which will be best calculated to provide for effective opposition to the disembarkation of a hostile force. And, to commence with, it should be understood that this is essentially a case of *passive defense*, and that troops especially kept in reserve are *not* required for counter-attack, but that their function is that of delivering a well-sustained fire at the last moment. In discussing the problem, the case of a landing unsupported by war-ships may be left out of account, as it only presents few difficulties; it is only when there is a covering fleet, or flotilla, on the spot that the defenders have to consider their own protection against fire, as well as to provide for bringing a maximum of fire to bear themselves.

Nautical considerations will usually oblige the transports to anchor at some distance from the shore. Now it is clearly a matter of vital moment that there shall be a hot fire on the landing troops from the earliest possible moment. The conditions of the case demand that the defenders shall begin thinning the numbers of their opponent from the very commencement. Supposing that the ships are lying half a mile, or upwards, from the beach, then the defending troops stationed down *near the water's edge* cannot be expected to bring really effective musketry to bear until the boats have traversed a considerable part of their way to the shore, and this in spite of the fact that at the outset the fire from the ships will probably not be very damaging because the defenders will not then have been properly located. In fact, unless a portion of the defending force has been posted on comparatively elevated ground, the chances are that the landing parties will not begin to suffer severe losses till they are getting near their goal. On the other hand, we have to remember that any troops posted in commanding positions are likely to be very roughly handled by the ships' artillery, and they may be so shaken by its effect that they will be making bad shooting when the boats are coming in close, just at the time when a well-sustained fire is especially necessary and when it ought to be especially effective. The truth is that if the topographical conditions will admit of it, some of the defending troops should be posted on high ground with a view to effective fire on the boats at the beginning while the flotilla is some way out from the beach, and that some of the defending troops should be posted on low ground, where they will suffer much less from the hostile guns and will be in a position to use their rifles to good effect against the boats, as these get in to close range.

It would, moreover, generally be advisable to keep some reserves low down and under cover until the approaching enemy was within, say, 200 yards of the shore, so as to ensure that there shall be accurate and well sustained musketry fire at the last moment, when its effect on crowded boats and on soldiery, scrambling as best they can out of boats on to a beach, should be tremendous. Reserve detachments held back for this final critical phase could be drawn up in relatively close formations, and it might often be possible to find small depressions, or positions behind hummocks or banks, from which they could fire obliquely on to the water close to the beach while themselves completely concealed from view of the enemy's warships. It may be suggested that in a case like this every rifle ought to be in the firing line from the very start, so that the greatest possible number of bullets may be poured towards the boats throughout their perilous voyage. But it is at the final phase, it is during those moments just before the enemy reaches the shore, that musketry will be most effective if the troops only keep cool and steady. By that time soldiers who have been under heavy shell fire and who have seen their antagonists approaching in spite of all their efforts, may begin to waver and are not unlikely to start shooting wildly. That is why troops who have been held in reserve may prove so valuable at the supreme crisis of the conflict.

The same general principle applies, it should be understood, to the posting of machine guns, which I shall refer to again further on. However skilfully such weapons may be disposed on high ground, machine guns up there are likely to be promptly discovered and to be silenced by the enemy's artillery after a short time. Some should be in commanding positions to bring effective fire to bear on the boats while these are still a long way out. Others should be reserved for the final stage, and should, if possible, be so emplaced that during those last few vital minutes they may be safe from the gunners on board ship.

There may, of course, be no high ground; or any high ground that there is may be so devoid of anything in the shape of cover as to make it impossible as a position for troops. You have to take your ground as you find it, and to adapt your line of battle to its peculiarities. The chalk cliffs of the south of England rise almost sheer out of the sea, dominating the adjacent waters, and they make capital positions for infantry as long as this is not being fired at; but, however inexperienced the naval gunners might be in the use of shrapnel, they could hardly fail to use that projectile effectively against so conspicuous and so exposed a target, because in the nature of things there is never much cover on chalk downs. On the other hand, it is almost certain that there will be some low ground available for occupation—if there is no low ground the locality cannot well be suitable for a landing-place from the enemy's point of view; and low ground, however destitute it may be of cover, always offers the advantage that the gunners of the warships will not be likely to make good shrapnel practice against troops posted on it, and that the enemy's artillery fire will cease just as the critical moment is at hand.

### THE CONTROL OF MUSKETRY

We now come to a question which is in reality of vital importance. It has been already pointed out that in some respects observation of fire is particularly easy when the target is an object afloat on the sea, because the strike of the bullet or projectile is clearly indicated by the splash. But this presupposes that the splash can be identified, *i.e.*, that a connection is established between the splash and the particular rifle or gun which discharged the bullet or the projectile that made the splash. Now, that is simple enough when a single rifleman is at work, or even when a small party of riflemen are delivering occasional shots; but supposing that a considerable number of infantrymen are blazing away for all they are worth at a flotilla of boats, the whole sea will be, so to speak, in a state of boil, and observation of fire, correction of ranges, and all the rest of it, become almost impossible. Nor should it be forgotten that corrections as regards range are likely to be very necessary when it is a case of rifles firing at objects afloat, for, as a matter of fact, judging distance across a surface of water happens to be particularly difficult. Let any infantry officer test his men in guessing the number of yards to a buoy or some such object out at sea of which he knows the range, and he will find that the results are deplorable. It is, in the nature of things, harder to judge distance correctly across water than across land, and in addition to this the factor comes in that troops rarely get any practice in the former exercise. Now, if a number of marksmen are firing independently they confuse each other with their splashes, nobody knows which splash is which, and the end of it is that they merely fire away without altering their sights on the chance that they have hit off the range. Musketry must, of course, be presumed to be under some sort of control, and section commanders may try to make some corrections for range; but they are no better off than the individual marksman as regards observations of results, if the whole water area is dotted with splashes resulting from the fire of their own and of other men. The consequence will be that, in spite of all the advantages which highly conspicuous targets like boats confer, and of the fact that every bullet which does not hit a boat tells its own tale, as it were, the damage done among the approaching adversaries is likely to be insignificant until these get close in.

The situation is in fact one which cries aloud for the employment of volleys; and it moreover cries aloud for volleys delivered by as large a body of troops as can conveniently be got to fire simultaneously at the same mark, because, from the point of view of observation of fire, the fewer the volleys are, the better. Each volley creating its own set of splashes round some particular boat, the officer ordering it will be able to correct for range. Volleys, moreover, offer other striking advantages. They bring it about that each detachment, be it a group or a section or a half company, devotes its attention to a particular boat until that boat is "knocked out." If a boat stops, it can safely be assumed to have lost so many men as to be out of action, and in any case it ceases for the time being to be a danger. The officer with his field glass speedily detects that the boat which his men are firing volleys at has stopped; the individual soldier, on the other hand, probably does not notice this circumstance, and he would not realize if he did that it is waste of power to go on firing at a boat which has come to a standstill. But all this, it must be understood, refers only to the situation during which the boats are still at some distance from the beach; when the boats approach to within short range—say a quarter of a mile—volleys must begin to give place to independent fire and eventually to magazine fire. But if the volleys are intelligently employed and if the musketry is reasonably accurate, they should have done much damage while landing parties are still a considerable way off, and they may even have stopped some hostile detachments altogether.

It is no doubt unfortunate, from the point of view of repelling landings, that volleys have disappeared out of our musketry manuals. But, after all, it is not a difficult undertaking to get a number of soldiers to discharge their rifles at the same time at the same object. Everybody knows the meaning of a volley—of a volley of stones and of a volley of oaths. Infantry told off to coast defense can soon be taught to fire volleys in the most approved style under service conditions, even in spite of text-books.

This rule with regard to volley firing when repelling a landing—for it is a rule—only applies, however, when the force of defenders is of such appreciable strength as to ensure that its volume of fire will be considerable. Supposing it to be the case of only a few scattered riflemen (such as might arise when the disembarkation was only being opposed by a detachment of cyclists hurried to the spot), then the *raison d'etre* for the employment of volleys disappears. Each man can watch his own shots and can make his own corrections. There is no question of a confusion of splashes, and it is interesting to remember that "Cyclist Training" contemplates such situations. Taking the case of the cyclist battalions which, amongst their functions as authoritatively laid down, include that of preventing an enemy landing—would it not be well if their *personnel* were occasionally practised in this firing at objects on the sea at unknown ranges, so that all ranks should learn to appreciate the special features presented by musketry under these peculiar conditions? "Cyclist Training" talks airily of "resolute action by a few riflemen" and of a "small body, boldly handled." What is required in the situation which the booklet conjures up is effective musketry from individual cyclists scattered about and in hiding, where each man carefully takes note of his own splashes and corrects his errors deliberately and coolly by personal observation of fire.

It cannot be too clearly understood that, although under modern conditions an opposed landing is one of the most difficult of all operations of war, its difficulty diminishes, and may even disappear altogether, if the musketry of the defending side is not under proper government. To realize the paramount importance of accurate rifle fire in this particular case you have only to remember that even a heavily loaded boat can travel fairly fast through the water—say, four miles an hour. The flotilla may take ten minutes to reach the beach from the transports, or it may take a quarter of an hour, or it may take longer; but the time will inevitably pass quickly, and great execution must in any case be done in a very short space of time if the hostile enterprise is to be nipped in the bud. For it is reasonable to assume that the enemy enjoys a considerable superiority in numbers, and that, if hostile troops once manage to reach the shore, they will succeed in making good their footing there while the boats speed back for a fresh contingent. If the rifles are to be effective there must be a well-regulated fire-discipline adapted to the special circumstances of the case, and it is high time that our official works dealing with musketry should devote some attention to the subject. The Army Council has recently been animadverting on the lack of proper fire control in the Territorial Army. How can officers of that force be expected to exercise fire control in face of a hostile landing if they are left without adequate instructions as to how the fire control is to be exercised?

### Machine Guns

Reference has already been made in some of the preceding paragraphs to machine guns. Of the value of this particular class of weapon to a force opposing a landing there can be no question whatever. They may almost be said to stand alone, inasmuch as they possess qualifications for this nature of combat superior to those that can be claimed for any other instrument for dealing out destruction to an enemy; and a moment's consideration will show that this is the case.

Boats present an ideal target to such a weapon. Thanks to the splashes on the water, the exact range can be readily ascertained—and kept. A machine gun has no nerves, and it can be trusted to do terrible execution amongst a mass of soldiers cooped up in so very confined a space. It can generally be effectively concealed in undergrowth or among rocks, so that the gunners on board ship will find the utmost difficulty in locating it; and it is therefore much less likely to be promptly silenced than a field gun (unless the latter be firing from behind cover, indirect methods of laying being employed). Anyone who has ever seen a maxim gun fired at a barrel or similar target in the sea must realize its immense potentialities as a means of beating off a hostile landing.

Very recently issued instructions prescribed that machine guns ought to work in pairs, because one of the two may get out of order and may jamb. Now, however sound this principle may be under normal tactical conditions (it is certainly sound in the case of machine guns at the corner of a square assailed by Fuzzy-Wuzzies), the principle is totally inapplicable to the case of opposing a landing, when that landing is supported by gun-fire. Owing to its extensive cone of dispersion, the heavy shrapnel fired by naval ordnance covers a large area with its bullets, and the well-directed shell which is intended for one of two machine guns disposed in pairs, will be likely to settle both of them. So far from their being disposed in pairs, or "massed," machine guns intended to defeat a landing ought to be distributed about along the defensive line to the utmost extent permitted by the conditions of the ground, not only with a view to their own security but also because of their value as range-finders to any infantry or mounted troops or cyclists who may be near them.

When, some years ago, Lord Esher's Committee pronounced itself upon the subject of War Office organization, the triumvirate declared that our army was at that time organized for purposes of peace rather than for purposes of war; and the General Staff was created to put an end to this ridiculous state of things. Now, to organize an army for war it must first be decided what tasks that army is likely to be called upon to perform in the event of a contest. When a conclusion has been arrived at on this point, an appropriate equipment and a suitable order of battle can be devised for the troops. Has this common-sense method of setting to work been followed in organizing the Home Defense Army, in so far as those portions of it which are to repel landings are concerned? Do the arrangements as regards machine guns afford any indication that it has? We look in vain in "War Establishments" for battalions with a specially large complement of machine guns. Even the cyclist battalions, which according to official pronouncements are definitely charged with the duty of beating off hostile landing parties, are each only furnished with two of these pieces. "Resolute action" and "bold handling" are all very well in their way, but what above all things the cyclists require is that they should be properly equipped for the special and anxious duties which are imposed upon them.

### MOUNTED TROOPS OPPOSING A LANDING

The firmest believer in the shock tactics of mounted men will admit that in this particular tactical situation cavalry, however well fitted it may be for combat in the saddle, is practically forced by the circumstances of the case to adopt the *rôle* of mounted rifles pure and simple. Onsets by troops of cavaliers, such as the Spanish horse so opportunely delivered on detachments of our troops discharged on the beach near Cadiz during the abortive attempt on that great place of arms by Rooke and Ormonde in 1702, must be set down as impracticable in face of the weapons of to-day. Acting as riflemen, however, mounted troops might prove extremely useful in opposing a hostile landing; and the conditions in certain respects confer special advantages upon all classes of mobile troops when dealing with such a situation.

For in a case like this, where there is no fear whatever of action by hostile horsemen, the mounted troops can safely proceed to a considerable distance from their chargers when they dismount; and this, needless to say, facilitates the concealment of these latter. Then, again, mounted troops can for the same reason hang on to the very last possible moment, supposing the efforts of the defenders to prevent the enemy from reaching the shore to have failed; they may thus be able to cover the retirement of the infantry at the crisis of the combat very effectually. If the terrain were favorable, mounted troops might, of course, prove very useful during the course of the struggle in moving from one point to another where danger especially threatened. If the country adjacent to the landing-place happened to be destitute of cross-roads and were broken in character, mounted men might well prove even more useful than cyclists during the combat. It arises from the strategical situation that there may only be mobile troops—mounted troops or cyclists—on the spot at the moment when an enemy is attempting to disembark, and that a supreme responsibility may be suddenly thrust upon them; any mounted troops of the Home Defense

Army detailed for local coast defense should therefore study this particular tactical problem of opposing landings, so that they may know how to act should they be put to the test. The principles laid down in earlier paragraphs dealing with the taking up of positions and with the control of musketry apply, of course, to mounted troops as well as to infantry.

### THE ARTILLERY OF THE DEFENSE

In some respects, be it understood, the gunners of a force engaged in opposing a landing have an especially easy task. The targets offered to them are sure to be well defined, and the splash of the shrapnel bullets on the water makes observation of fire particularly simple. On the other hand (unless the guns are emplaced behind cover and indirect methods of laying are used), they are likely to be overwhelmed with projectiles from the enemy's fighting ships, because they offer a good mark and because look-out men aloft provided with telescopes are sure to speedily locate them.

The value of Artillery to the defense, if that Artillery can only manage to keep in action, can hardly be exaggerated. Even a battery of light guns—Horse Artillery or mountain guns—would make things uncommonly uncomfortable on board a crowded transport that anchored within range. The presence of guns on the defending side (always with the proviso that they are not silenced by the heavy metal of the covering fleet) would perhaps compel the transports to anchor at a long distance from the beach; and it is hardly necessary to point out the difference to the enemy if his boats have to travel, say, 4000 yards instead of, say, 1500 yards. Howitzers, firing from behind cover, with their big shells and high explosives, would almost certainly oblige the transports to lie well out, because the ships' gunners could not silence them. It in fact shows how necessary it is that Artillery *personnel* which is detailed for guarding possible landing-places should be *au fait* with all the tricks of firing from behind cover with quadrant elevation.

An examination of the question of the handling of the artillery of the defense will be facilitated if we remember what the enemy's preparatory procedure is likely to be. The transports will probably be moored broadside on to the shore, the boats will be brought round to their outer side, and the landing parties will then get into the boats, the transport in each case forming a traverse protecting them from fire until they start for the shore. Transports are, of course, of various kinds; but, speaking generally, there would be little cover on their upper decks, and the more plunging the fire from the shore turned out to be the less satisfaction would be this cover. On the other hand, troops in boats waiting on the outer side of a transport for the signal to make for the shore would be practically secure against any but very plunging fire. In other words (assuming that we are dealing with guns and not with howitzers), as the range of the defenders' artillery from the transports increased, the effect of its fire would grow greater. In fact, in so far as the transports were concerned, there would be a certain amount of temptation to place the defending guns a good way back from the shore, an arrangement which would further have the advantage of making it more difficult for the enemy to silence them, supposing that they were not emplaced behind cover. But against this must be set important fact that, once the boats start for the shore, the shorter the range for the defending guns is, the greater the effect of their shrapnel is likely to be, provided only that they manage to keep in action.

I set great store by howitzers for this particular situation. Any gunner will tell you that a howitzer is not an ideal piece for firing at a moving target; but he will also tell you that a howitzer can bring plunging fire to bear at short ranges from behind cover, and that a gun cannot do this. There is, in fact, a great deal to be said for the howitzer for purposes of opposing hostile landings. Howitzer fire ought to be especially effective against the transports; and when the boats start for the shore, howitzers will be able to go on firing at them from positions behind cover where the ships' guns cannot silence them. The merits of the howitzer are perhaps best realized if it be remembered that, supposing the enemy to be supported by a number of war vessels, the powerful field guns of the present day with their flat trajectories may not be able to remain in action against the landing parties, because, to enable them to bear on the boats, they will probably have to be out in the open, where they will be at once detected.

In dealing with this tactical situation of opposing a landing, the special *rôle* of the artillery would seem to be that of overwhelming the boats with bullets during the stage preceding that when skilfully controlled musketry can be expected to have much effect on their living freight. Supposing, for instance, that the transports are moored at 2000 yards from the shore, then we might put it that the special *rôle* of the guns was to keep up fire till the boats were within 1000 yards of the shore, and that, even if they had by that time been silenced, they would have satisfactorily performed their task. In other words, the commander of the battery, or section of a battery, while doing his utmost to hide his guns, must not sacrifice fire-effect on that account during that phase of the combat where their shells may be especially valuable.

The lie of the land and the position of shoal water near the landing-place will sometimes permit of guns being so posted that they can bear upon the water-area to be traversed by the boats, while remaining, thanks to the rising ground on the flank, defiladed themselves from the enemy's war-vessels. Supposing, for the sake of example, that the landing-place is within a comparatively shallow bay into which battleships and cruisers cannot safely penetrate for want of water, then there might be ground near the promontories which flank the bay, from which guns could sweep its surface very effectively, while safe themselves from the fire of the hostile warships. A careful study of the charts might, in fact, at times prove very illuminating; by examining them it might be discovered that certain portions of the water-area were closed to vessels drawing more than a very few feet of water. Those responsible for the defense must fully grasp the influence which local conditions of this kind may exert, must look at the situation from the enemy's point of view, and must frame their plans accordingly. The adversary is not going to jeopardize valuable units of his sea-going fleet in supporting landing-parties, and is sure to give shoals a very wide berth for fear of accident. The armada may, of course, be accompanied by armed craft of shallow draught; but the defending artillery will naturally have much less to fear from the few small-caliber guns of such unsteady vessels than from the formidable batteries of battleships and cruisers.

This reference to craft of shallow draught brings us to the last point of which I propose to treat.

### DEALING WITH FIGHTING SHIPS OF SHALLOW DRAUGHT WHICH MAY BE COVERING A LANDING

Abercromby's landing in Aboukir Bay was very effectively seconded by shallow-draught gun-vessels which had been especially fitted out for the purpose; and it is likely enough that an enemy proposing to disembark troops on the shores of this country, and anticipating resistance, would adopt similar precautions. Now, the proper way to proceed against craft of this class is to leave them alone. They may offer tempting targets. One does not like to be peppered without giving something back. A few skilful marksmen ensconced among bushes 500 yards off might make things uncomfortable enough for the layer of a 6-pdr. perched up in the air on a destroyer. But the great point to bear in mind is that the task in hand is to prevent a landing, and that the enemy's boats are, therefore, the proper target to fire at; if the boats can only be stopped it does not matter much what happens to the covering fighting craft. It is, of course, possible to conceive situations where it would be justifiable to fire on such vessels. No tactical law is so absolute that it must under no circumstances be broken. But, for practical purposes, the rule enunciated above—the rule that they ought to be left severely alone—is quite good enough.

### A SUMMARY OF THE MAIN POINTS TO BE REMEMBERED

Before concluding, it seems desirable that I should indicate briefly the most important of the numerous special points which seem to arise when a force is charged with the repelling of a hostile landing. It will be assumed that the landing is covered by the gun-fire of hostile war-ships, and that it is taking place on an open beach.

1. To ensure effective fire against the approaching boats while these are still a long way out, part of the force should, if possible, be stationed on commanding ground. On the other hand, as troops on commanding ground are liable to suffer severely from the fire of the enemy's ships, part of the force should be on low ground, so that there may be effective fire on the boats when these get close in.

2. In this case the function of the reserves is not the delivery of counter-attack. Reserves should be kept concealed close to the beach, ready to open sudden well-directed fire at the last moment before the boats reach the shore.

3. As naval artillerists will find ill-defined targets on land particularly difficult to deal with, the neighborhood of prominent objects should be avoided and the defending troops should be well scattered.

4. Infantry, cyclists, and mounted troops acting dismounted, should as a rule employ volley fire until the boats approach fairly close to the shore.

5. Troops detailed for local coast defense in time of war should be pratcised in musketry, machine-gun fire and artillery fire (as the case may be) at targets on the sea in peace time.

6. Machine guns are ideal weapons for this kind of tactical situation. They should not work in pairs, but should work singly. A proportion of two of them per battalion is totally inadequate; four per battalion may be taken as a bare minimum, and one per company as the correct proportion. Cyclists, or ordinary battalions detailed for local coast defense in time of

war, are not properly equipped for the performance of the task imposed on them, if they are provided with only two machine guns.

7. Howitzers, owing to the fact that they should always be able to find concealed sites to fire from at transports, and that they can toss their projectiles from behind cover at targets within short range of them, are of great value for opposing landings. Field or horse artillery guns may be unable to bring their fire to bear from behind cover either on the transports or on the boats, and if they are in action in the open they are likely to be promptly silenced.

8. All the attention of the defenders should be devoted to the actual landing troops; small craft which may be assisting these with their fire should be ignored.

9. Official instructions, designed to deal with the tactical problem presented to a force which is opposing a landing, must be issued by those who are responsible for the fighting efficiency of the army.

Most tactical questions admit of considerable difference of opinion, and it is possible that many authorities on the art of war would dissent from some of the views which have been expressed by me this evening, and might not concur in certain of the doctrines which I have just enunciated. But on one point there can be no divergence of views. The British Army is entitled to ask that the General Staff shall provide it with regulations and instructions to guide it in *all* classes of operations which it may be called upon to carry out in time of war. A portion or portions of it may in the future have to repel or to delay the landing of hostile troops in this country. It will be somewhat late in the day to begin elaborating theories as to how such a situation should be dealt with after the enemy has made the attempt —and has succeeded in the attempt. Until the subject of opposing landings has been included either in "Field Service Regulations" or in "Combined Training," or in both, those manuals do not properly provide for the requirements of the Service. But in saying this I have no intention of adversely criticizing the work of the small and numerically inadequate section of the General Staff at headquarters which deals with the preparation of books of this kind and of educational works in general. You cannot make bricks without straw, and you cannot get necessary books and instructions compiled if you have not got the *personnel* to carry out the task. The duty in this connection which is imposed upon the General Staff does not seem to be grasped in the proper quarter, nor do its responsibilities in the matter appear to be realized at the top.—*National Defense.*

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## THE COAST DEFENSES OF TURKEY

Translated from the *Russian Artillery Journal*, August, 1912

BY LIEUTENANT J. K. L. FITZWILLIAMS, R.H.A.

### GENERAL REMARKS

The Coast Defenses and fortified forts possessed by Turkey are few in number and, generally speaking, do not merit serious attention, as they do not answer the requirements of present-day methods of defense, either from an engineering or an artillery point of view. The only exceptions are those of the Dardanelles and Bosphorus, whose defenses in 1887 were considerably improved and strengthened and even now are in a fairly satisfactory condition. The land defenses of Constantinople have been much improved of late years, and according to a map issued in Germany, consist of a regular system of separate forts connected by batteries.

In this article attention will only be paid to the coast defenses of the Dardanelles and Bosphorus.

In these days of high explosive shell and Q.F. guns, long and narrow straits require a special form of coast defense. Guns do not need to be of particularly long range provided that the batteries are carefully sited to suit the terrain, and are capable of bringing a heavy volume of fire to bear on the required objective.

The guns used by Turkey along the coasts are nearly all made by Krupp, while her naval guns are mostly supplied by Armstrong and Elswick.

### THE DARDANELLES DEFENSES

The Straits of the Dardanelles (or the Hellespont, as they used to be called) connecting the Ægean Sea with the Sea of Marmora, have a total length of 42 miles, a width varying from 1400 yards to 8200 yards and a depth of from 70 to 350 feet. A strong current flows from north to south and considerably impedes navigation. There are two important islands in the Ægean Sea near the entrance to the Straits, their names are Imbrus and Tenedos.

Opposite Tenedos lies Besika Bay, which is a good roadstead and is often visited by European squadrons, to whom the entrance of the Dardanelles is forbidden.

At Besika Bay is a fort of modern construction, and a wireless station.

During the last twenty-five years the defenses of the Straits have been much improved. Batteries have been constructed covering the narrower portions of the Straits.

The southern entrance is guarded by the batteries at Kum-Kale on the Asiatic, and Seddil-Bahr on the European shore. They are separated by a distance of 4060 yards, and are built in the immediate vicinity of the ancient castles of the same names erected by Mahomet IV in 1659. The defenses will be enumerated in order, starting on the European shore from the south, *i.e.* from the Ægean Sea towards the Sea of Marmora.

#### A. ON THE EUROPEAN SHORE

1. Ertrogrul Battery, situated to the east of Cape Challas, on the edge of a small bay, is armed with eight 9.4-inch guns.

2. Seddil-Bahr Battery, constructed in 1886 at the extremity of the Gallipoli Peninsular in the Ægean Sea near the ancient stone castle of Seddil-Bahr. The battery is square in shape and has large low towers at each corner, and is now used as an arsenal and powder magazine. Near the castle is a searchlight apparatus. The armament of the battery consists of six Krupp 11.2-inch, 10.2-inch and 9.4-inch guns. There are also six field guns.

3. Souan-Dere-Tabia Battery, armed with three 47-mm. Nordenfeldt guns, watches the area covered with mines between Capes Souan-Dere and Cephas.

4. Tldiz-Tabia Battery, constructed on a hill 300 feet above sea level, is designed to operate against ships, which from a position in Sare-Siglarsok

Bay might take in flank the batteries Kamidie and Chemenlek (on the Asiatic shore). It is armed with fourteen 8.3-inch and 5.9-inch guns.

5. Nordenfeldt-Tabia Battery, situated a little to the right and lower than Tldiz-Tabia, is armed with seven 47-mm. Nordenfeldts.

6. Kamidie Battery, near Cape Kidil-Bahr, is armed with two 14-inch, three 47-mm. Nordenfeldts, and one field gun.

7. Namazie Battery, situated at the narrowest part of the Straits, is semicircular in shape and has sixteen guns of from 10.2-inch to 8.3-inch caliber, and also one field gun.

This is the most important work on this side of the Straits and stands 35 feet above sea-level.

Close by is an ancient stone fort built in 1470 by Mahomet II. It is now in ruins. The narrowest part of the Straits is between Kidil-Bahr and the town of Chanak. The current here flows at 5¼ miles an hour. The width of the Straits is only 1400 yards.

8. Medjid Battery is armed with six 9-inch and one field gun.

9. Kamidie-Mouavin-Tabia Battery is situated slightly higher than Medjid battery, and is armed with six field guns.

10. Konidje-Su-Tabia Battery possesses four 5.9-inch and 8.3-inch howitzers.

11. Pallas-Baba-Tabia Battery is on the same hill as No. 10 and has the same armament.

12. Dourmin-Bournu Battery is constructed to the south of Namazie Battery and consists of seven 9.5-inch and 8.3-inch guns. Also one field gun.

13. Mouavin-Dourmin-Tabia Battery is situated on a hill above No. 12, and is equipped with three field guns.

14. Cham-Bournu-Tabia Battery lies to the north of No. 13 on about the same level, and is armed with two 5.9-inch guns.

15. Lodas-Tabia Battery is built on a small hill lying north of the village Maitos, and is armed with two 5.9-inch guns.

16. Porus-Tabia Battery also possesses two 5.9-inch guns. Close to it stands the ancient stone fort Bokkal-Kale, now in ruins, from which runs a submarine cable connecting it with Nagara (on the Asiatic shore).

17. Bokkal-Tabia Battery is the left flank of the defenses on the European side of the Dardanelles, and possesses two 5.9-inch guns. It stands on a headland near the village Bokkal and has a lighthouse close to it.

All the forts along the European shore are connected by a high road, kept in good repair, and also by telegraph and telephone.

Gallipoli (50,000 inhabitants) possesses a good harbor and was the first part of Europe occupied by the Turks. The land defenses of the town are weak and out of date, and could easily be turned by a force disembarking in Kisserosk Bay. The Turks have often proposed improving the defenses, but owing to lack of money nothing has been done.

### B. ON THE ASIATIC SHORE

Considerable alterations have been made in the defenses on this side of the Straits since the war of 1877-78. The main forts are as follows:—

1. To the east of the old castle at Kum-Kale stands a new fort commanding the entrance to the Dardanelles at its junction with the Ægean Sea. It covers the area reaching to Seddil-Bahr (on the European shore).

It is armed with ten guns varying from 11-inch to 5.9-inch caliber. It also has six field guns and three 47-mm. Nordenfeldts.

2. Orchanie Battery stands on a high hill to the south-west of Kum-Kale. It has seven 9.5-inch guns, whose fire covers the entrance and all approaches to the Straits.

3. Dardanus Battery contains two Q.F. 5.9-inch Krupps.

4. Cephas-Tabia Battery lies to the north of Cape Cephas lighthouse and is armed with three 47-mm. Nordenfeldts.

5. Kamidie Battery stands on the shore of Sari-Siglarsok Bay and has fifteen guns varying from 11-inch to 5.9-inch caliber.

6. Chemenlek Battery has four heavy guns, four 47-mm. Nordenfelts and eleven field guns. This battery also has a searchlight apparatus and is connected by a submarine cable with Namazie battery (in Europe). This is the strongest and best equipped battery on this shore. Under the ruined castle of Chanak, which stands in the vicinity, is a large ammunition store.

7. Medjid-Kavan-Tabia Battery is barely visible from the sea. It is armed with nine field guns.

8. Medjid Battery is armed with fifteen heavy guns.

9. Nagara Battery is the right flank of the Asiatic defenses of the Dardanelles and has nine guns varying from 10.2-inch to 5.9-inch caliber.

10. Abilos-Tabia and

11. Maltepe-Tabia Batteries are both situated on the crest of a hill near Cape Nagara, and have each two guns of medium caliber.

### REMARKS

It is interesting to note that Nagara Battery was constructed on the ruins of the village Abidos, near which Xerxes ordered a bridge to be built for the passage of his army across the Straits.

All the batteries have been built with great care, and with the exception of Kamidie and Namazie (on the European shore) are practically invisible from the sea. Their position is, however, easily detected owing to the stone barracks, which in every case have been built close behind them and are in full view of passing ships.

Provided that the batteries are well manned and well handled it seems almost impossible for any warship to safely run the gauntlet of the Straits. Between Capes Cephas and Nagara there are 107 guns of the latest pattern, and the fire of these ought to be able to stop any ship, impeded as it will always be by a current running at the rate of about 4¾ miles an hour.

The total garrison of the Dardanelles defenses amounts to 2560 men.

### THE BOSPHORUS DEFENSES

The Sea of Marmora joining the Dardanelles with the Bosphorus is 170 miles long and 66 miles wide at its narrowest part.

The Bosphorus joining the Sea of Marmora with the Black Sea is 18 miles long and from 100 to 350 feet deep. The greatest width is 3800 yards, while the narrowest portion is only 700 yards across. The current flows at about 5¼ miles an hour.

On account of its width the Bosphorus is even better equipped by nature than the Dardanelles for opposing the passage of a hostile fleet. From an artillery point of view the batteries are not as strong as those on the Dardanelles.

## TABLE SHOWING THE NUMBER OF GUNS AND GARRISONS OF THE VARIOUS BATTERIES ON THE DARDANELLES

| Name of Battery. | No. of Guns. | Officers. | Rank and File. | Companies. | Battalions. | Regiments. |
|---|---|---|---|---|---|---|
| 1. Ertrogrul | 8 | 4 | 80 | 1 | 1 | 1 |
| 2. Seddil-Bahr | 12 | 14 | 240 | 3 | | |
| 3. Souan-Dere-Tabia | 3 | — | — | — | 1 | |
| 4. Tldiz-Tabia | 14 | 4 | 80 | 1 | | |
| 5. Nordenfeldt-Tabia | 7 | — | — | — | | |
| 8. Medjid | 7 | 9 | 160 | 2 | | |
| 6. Kamidie | 6 | 5 | 80 | 1 | | |
| 9. Kamidie-Mouavin-Tabia | 6 | — | — | — | | |
| 7. Namazie | 17 | 18 | 280 | 4 | 1 | |
| 11. Pallas-Baba-Tabia | 4 | 1 | 20 | | | |
| 10. Konidje-Su-Tabia | 4 | 1 | 20 | | | |
| 13. Mouvain-Dourmin-Tabia | 3 | — | — | | | |
| 12. Dourmin-Bournu | 8 | 14 | 160 | 2 | 1 | |
| 14. Cham-Bournu-Tabia | 2 | 1 | 55 | 2 | | |
| 15. Lodas-Tabia | 2 | — | 15 | | | |
| 16. Porus-Tabia | 2 | — | 15 | | | |
| 17. Bokkal-Tabia | 2 | 3 | 75 | | | |
| Total (Europe) | 107 | 74 | 1280 | 16 | 4 | 1 |
| 1. Kum-Kale | 19 | 14 | 240 | 3 | 1 | 1 |
| 2. Orchanie | 7 | 4 | 80 | 1 | | |
| 3. Dardanus | 2 | 1 | 20 | 3 | 2 | |
| 4. Cephas-Tabia | 3 | — | — | | | |
| 5. Kamidie | 15 | 12 | 220 | | | |
| 9. Nagara | 9 | 11 | 140 | 2 | | |
| 11. Maltepe-Tabia | 2 | — | 10 | | | |
| 10. Abilos-Tabia | 2 | — | 10 | | | |
| 6. Chemenlek | 19 | 14 | 240 | 3 | | |
| 8. Medjid | 15 | 17 | 300 | 4 | 1 | |
| 7. Medjid-Kavan-Tabia | 9 | 1 | 20 | | | |
| Total (Asia) | 102 | 74 | 1280 | 16 | 4 | 1 |
| Grand Total | 209 | 148 | 2560 | 32 | 8 | 2 |

Beginning at the Sea of Marmora the chief forts on the Bosphorus are as follows:

### A. ON THE EUROPEAN SHORE

At the entrance to the Bosphorus stands a disused fort called Rumel-Kissar, connected by submarine cable with Cape Kandidge (in Asia). It was from this point that Darius witnessed the passage of his army across the Straits. It was also here that the Crusaders crossed into Asia.

1. Kirich-Bournu Battery is of new construction and is armed with four old pattern 6-inch guns.
2. Telle-Tabia Battery, situated on a Cape of the same name, has two 8.3-inch howitzers on the summit of a hill, two 150 mm. Armstrong shielded guns lower down, while on the seashore near an old Genoese castle are mounted two Nordenfeldts and a searchlight apparatus.
3. Rumel-Kavak Battery has two 14-inch Krupp guns and one 9.4-inch howitzer.
4. Rumel-Kavak Fort is armed with six new pattern guns.
5. Saritash Battery on the seashore is armed with four 9.4-inch Krupps and two Nordenfeldts.
6. On Cape Mavromolo 500 yards north of Saritash Battery is a newly constructed concrete observing station and four howitzers.
7. Boyuk-Leman Battery is armed with four 9.4-inch Krupps. There are also a searchlight apparatus, observing station, and ammunition store.
8. Karibdje Battery is situated on a Cape of the same name, and has four heavy guns.
9. Fort Kilia on the Black Sea, 6 miles from the entrance to the Bosphorus, is armed with seven 6-inch Krupps.

### B. ON THE ASIATIC SHORE

1. Madjar Battery, 930 yards north of Cape Muk-Bournu, is a large square earthwork on the seashore, armed with twenty Krupp guns varying from 6-inch to 11-inch caliber. This is the main fort on the Bosphorus.
2. Behind and higher up than the last battery is a work containing two Nordenfeldt and four field guns.
3. Still higher on the same hill are four 9.4-inch howitzers.
4. Anatole-Kavak Battery lies opposite Rumel-Kavak Battery (in Europe) and is separated from it by a distance of 1200 yards. It contains eleven Krupp guns.
5. Immediately above the last battery is an earthwork containing four 9.4-inch guns and four maxims.
6. On the shore of Kichili Bay is a battery of two 9.4-inch guns.
7. Phil-Bournu Battery lies to the south-west of the Cape bearing the same name and contains three 6-inch guns.
8. On Cape Poras is an ancient fort containing a number of antiquated pieces of ordnance.

Anatole-Phenar-Kissar Battery is armed with new pattern guns of varying caliber.

10. On Cape Boyuk-Bournu, jutting out into the Black Sea, is a battery of two field guns, while on a headland north of the mouth of the river Reva there are four field guns.

Many of the Bosphorus and Dardanelles Batteries are constructed either in or under the cliffs, and in many cases there is no adequate protection for the detachments against splinters of rock, etc.

—*Journal of the Royal Artillery.*

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## REPORT ON OUR COAST DEFENSES

The report of the board appointed to consider whether changes should be made in the coast defenses of the United States was made public Feb. 18 by the House Committee on Appropriations, during the consideration of the Fortifications bill.

The board was composed of Mr. Breckinridge, the Assistant Secretary of War, and Generals Wood and Weaver, Crozier and Kingman. The board's recommendations follow:

"After full consideration of the question presented by the Secretary of War the board finds:

"That the old type 12-inch guns and mortars are not equal in range and power to major caliber guns afloat.

"That by such minor changes in the carriage of the old type 12-inch guns at present emplaced as will permit an elevation of fifteen degrees, and by the provision of a certain proportion of lighter projectiles of approximately 700 pounds weight, an effective range of about 20,000 yards can be given these guns; that these changes should be made.

"That the great majority of our 14-inch guns, with certain slight changes which have already been ordered, and by the supply of a portion of the projectiles of lighter weight than the heaviest now furnished, are suitable in power and range to meet any that may now be brought against them.

"That the present emplacements are as a whole satisfactory, with the possible exception of some of the older magazines, which should be more thoroughly protected against plunging fire; that this protection should be furnished.

"That a policy should be adopted of providing, through annual appropriations, for such modernizing of fortifications as will result in keeping pace with the improvement in armament afloat.

"That in the case of those works where modernizing involves very extensive changes in emplacement, gun carriages, etc., it will be policy to construct new works and provide new armaments adequate for the demands of the situation.

"That the old works should be held when practicable and desirable as a secondary line of defense.

"That wherever it may be necessary to construct new works, especially at important points such as the entrances of our principal harbors, naval bases, etc., the major caliber gun should be at least a 16-inch 45-caliber gun mounted so as to have the greatest possible protection and an all-round fire where it may be necessary to have such fire.

"That the mortars to be installed in future should be of not less than 12-inch caliber, with a range of at least 21,000 yards.

"That this weapon should be the numerically preponderant type in our coast defenses, as it is cheap, has a long life, can be easily protected, is very effective against ships, and can be used as a valuable adjunct for the land defense. It must not, however, at any important point be adopted to the exclusion of high power direct fire guns.

"The general policy with reference to seacoast defenses should be to have the armament there emplaced of greater range and power than any which can be brought against it."

### GENERAL WEAVER'S TESTIMONY

In his testimony before the sub-committee of the House Committee on Appropriations, Feb. 3, General Weaver, Chief of Coast Artillery, expressed the opinion "that our system of fortifications is reasonably adequate for all defensive purposes which they are likely to be called upon to meet." This assumes that a sufficient trained personnel is provided, and such modifications of guns and carriages as have been recommended. Exception is made of Cape Henry, San Diego, San Pedro and a few other places which are under consideration. General Weaver considers an allowance of ammunition for two hours' firing of all the guns at a maximum speed liberal. This is for a 3-inch gun, 400 rounds; for the 6-inch gun, 250 rounds; for the 12-inch gun, 90 rounds; for the 14-inch gun, 80 rounds; for the 12-inch mortar, 100 rounds; for the 16-inch gun, 70 rounds. At the end of the two hours the guns would have approached the limit of their accuracy life. At 10,000 yards the guns can get approximately twenty per cent of hits. Mortars are fired up to 12,000 yards and their accuracy is about the same at all ranges.

The maximum elevation of the 12-inch gun is ten degrees and its range 13,186 yards, approximately eight miles, with a projectile of 1046 pounds. It is our most effective projectile. The range would not be increased by mounting on a barbette carriage, but the disappearing carriage could be altered to permit a maximum elevation of fifteen degrees, giving a range with a 700-pound projectile of 19,500 yards; approximately eleven miles. The 15-inch guns on battleships have a range of 1500 yards in excess of this. The 700-pound projectile could not penetrate the heavy armor, but would have a very destructive effect on the thin armor or unarmored parts of the vessel. Little damage, if any, could be done to fortifications by long range fire, but battleship guns with a range of twelve miles could bombard cities.

General Crozier interposed to say that we have a few 12-inch guns (nine 40-caliber guns) mounted which have a range of 22,000 yards. We have in all one hundred and four 12-inch guns, twenty-nine in barbette and seventy-five on disappearing carriages. These are 35-caliber.

General Weaver: "The ranges of the mortars—that is, the old mortar with the 1046-pound projectile—is approximately 12,000 yards, and the new steel mortar with that projectile approximately 15,000 yards; with the 700-pound projectile the old steel mortar has a range of 15,000 yards and the new mortar 20,000 yards."

We have had only one powder charge so far; that is, a powder charge that gives us approximately 2250 feet muzzle velocity. It is comtemplated that the bores of the chambers of some of the guns will be modified and enlarged slightly so as to enable us to burn more powder and in that way increase the muzzle velocity to over 2300 feet.

General Crozier here stated that the life of a 12-inch gun fired at a velocity of 2250 yards is about 300 rounds. He admitted, however, in reply to an expression of incredulity on the part of General Weaver, that the life of the high power guns was only one-half as much. In a subsequent statement General Weaver said he had in mind the service to which our 12- and 10-inch guns now mounted had already been subjected. General Crozier's figures were entirely new and are based upon the substitution of a broader rotating band upon the projectile, which prevents the escape of gas, thus lessening erosion. Some of the old 12-inch naval guns firing with high velocity have an accuracy life of only forty rounds.

General Weaver gave strong testimony in favor of the Crozier-Buffington disappearing gun carriage. He believes that a majority of our Artillery officers share this opinion. He has great expectations of the Hammond radio-controlled torpedo. He has no opinion of the Isham shell, which overlooks the fact that the principle of equal transmission of pressure through liquids applied only to confined liquids, and that the effect of the downward blow would be simply to blow the water away, as it did the sand in the firing test, and the pressure would not be transmitted; the principle did not apply to a free-surface liquid. To be effective a projectile should be capable of piercing armor.

General Weaver believes that our coast guns should be mounted so as to give an all-round fire, to provide for an attack from the land side; not necessarily shrapnel, but a high explosive shell with an instantaneous fuse. We now have three 10-inch guns that can be used in this way. Our mortars have an all round fire, but there is difficulty in developing a time fuse for shrapnel to be fired from them.

It is in contemplation to use submarines as an auxiliary to fortifications when the water is too deep for mining.—*Army and Navy Journal.*

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## RANGE OF OUR GUNS

The limits of range at which the fire of modern seacoast cannon can be controlled are shown in tables of maximum ranges which appeared in print for the first time in the hearings on the Fortifications Appropriation bill. The extreme range of the 16-inch gun as it will be mounted in the Panama fortifications will be 18,579 yards. The tables are given herewith.

TABLE I.—*Maximum ranges of naval guns*

| Caliber, type and length | Weight of projectile *Pounds* | Muzzle velocity *Ft.-sec.* | Elevation *Degrees* | Range *Yards* |
|---|---|---|---|---|
| 12-inch U.S. Navy, 50-caliber..... | 870 | 2,900 | 15 | 24,000 |
| 12-inch U.S. Navy, 45-caliber..... | 870 | 2,700 | 15 | 22,000 |
| 14-inch U.S. Navy, 45-caliber..... | 1,400 | 2,600 | 15 | 21,000 |
| 12-inch British, 50-caliber........ | 850 | 3,010 | 15 | 24,874 |
| 13.5-inch British, 45-caliber ...... | 1,250 | 2,700 | 15 | 21,658 |
| 15-inch British, 45-caliber........ | 1,950 | 2,500 | 15 | 21.193 |
| 15-inch British, 45-caliber........ | 1,950 | 2,500 | 45* | 46,290 |
| 12 inch U. S. Army, 35-caliber.... | 1,070 | 2,250 | 45* | 35,395 |

* Not used.

Under the appropriations carried by this year's Fortifications bill, steps will be taken by the War Department to increase the range of the 12-inch coast defense guns. This will be done by the modification of the disappearing carriages at a cost of $220,000. The carriages will be changed so that the guns can be fired at an angle of fifteen degrees, and a new type of projectile weighing 700 pounds will be built for the 12-inch guns. With this combination the range of 12-inch guns on disappearing carriages will be increased from 15,500 yards to 19,500 yards. A supply of the present type

of 12-inch projectile weighing 1046 pounds will be kept on hand and they will be used for shorter range fire. This will be with the long-pointed projectile. The table (p. 246) shows the range of 12-inch guns at ten degrees elevation, but with the modified carriage the elevation will be increased to fifteen degrees. While the striking energy of the gun is decreased by the reduction in the size of the projectile, it is believed that it will be sufficient to be effective against most modern battleships. The range of 18,579 yards for the 16-inch gun in the Panama fortifications could be increased, but this is sufficient for the defense of the waterway against any attacking fleet. English experiments show that heavy guns fired at 3000 yards have eighty-one per cent of the penetration of those fired at 1000 yards.

—*Army and Navy Journal.*

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## EXTRACTS FROM THE 1914 REPORT OF THE CHIEF OF STAFF, UNITED STATES ARMY

### COAST ARTILLERY CORPS

As to the Coast Artillery branch of the Army, the strength of that corps must necessarily depend on the number and character of the coast defenses which it is required to man. Its strength has no relation to the strength of the mobile Army other than that the strength of the latter must be adequate to protect the fortified positions from attack from the rear.

Under the present approved policy of the War Department the Coast Artillery defenses in our foreign possessions are to be manned entirely by organizations belonging to the regular service. The Coast Artillery defenses in the United States proper are to be manned at the rate of 50 per cent of the gun and mortar defenses by the Coast Artillery Corps of the Organized Militia.

The strength of the Coast Artillery of the Regular Army, from latest returns, is 746 officers and 17,201 enlisted men. The estimate of the Chief of Coast Artillery shows that 1312 officers and 30,309 enlisted men of the Regular Army in addition to the 740 officers and 18,531 enlisted men of the Organized Militia required to man 50 per cent of the gun and mortar defenses in the United States are necessary to man the seacoast defenses now existing at home and in our foreign possessions. As the authorized strength of that corps of the Regular Army is 748 officers and 19,019 enlisted men, it is at present 2 officers and 1818 enlisted men below its authorized strength and 566 officers and 13,108 enlisted men below the necessities as estimated by the Chief of Coast Artillery, in addition to the deficiencies in the Coast Artillery Corps of the Organized Militia. The total deficiencies in the Coast Artillery Corps of the Regular Army and the Organized Militia are, therefore, 856 officers and 24,489 enlisted men.

### DISTRIBUTION OF THE COAST ARTILLERY

The companies of the Coast Artillery Corps are distributed as follows.

| | Cos. |
|---|---|
| On the Atlantic, Pacific, and Gulf coasts of the United States proper.... | 140 |
| In Texas (equipped and acting as infantry)........................ | 5 |
| In our foreign possessions.......................................... | 25 |

| That is: | Cos. |
|---|---|
| In the Philippine Islands | 11 |
| In the Hawaiian Islands | 8 |
| In the Panama Canal Zone | 6 |

The aggregate enlisted strength of the Coast Artillery Corps required to man the coast defenses in the United States is reported by the Chief of Coast Artillery to be 24,075; the actual number available is 14,633. The aggregate enlisted strength required to man the coast defenses in foreign possessions now completed, or to be completed in the near future, as reported by the Chief of Coast Artillery, is 6234; the actual number now in those possessions is 2568. It therefore appears that there is a deficiency of 9442 enlisted men for the home coast defenses and 3666 for those in our foreign possessions.

Naval armament in the last few years has rapidly developed, particularly in respect to the caliber of the guns, their ranges, and the rapidity with which fire from these guns can be delivered. At the present time the tendency is to place on the higher type of battleships guns as large as 15 inches in caliber. These guns, whilst carrying a projectile of less weight than those used with our direct-fire type of seacoast guns, have, owing to the greater length of the guns and the higher powder pressures used, a very distinct advantage in range, their range exceeding that of our 14-inch guns from 2000 to 3000 yards. Whilst this advantage in range is to a degree offset by the instability of the naval platforms and the less accurate methods of obtaining ranges from ships than from land defenses, there still appears to remain a distinct advantage in this respect, which, coupled with the number of these caliber guns now being carried on the stronger type of naval ships, makes it necessary to give careful consideration to the question whether there should not be a change, not only in the length, caliber, and powder pressures of our heavier type of guns, but whether there should not be a change in the emplacements so as to give overhead protection to the crews operating the guns. In other words, it is my opinion that careful consideration should be given, at least in the establishment of new defense districts, to the question of the caliber, length, and range of the seacoast guns, as well as to the question whether the turret system for the protection of the gun and its crew should not be adopted, in order to put the land defenses somewhat nearer on a parity with the naval guns which are liable to attack them. As a fleet of 8 battleships of the most modern type can throw against a single target 118 projectiles per minute, the danger that must arise from the possibility of fragments of these shells and the débris thrown up from their impact against the concrete parapets which protect the guns to the crews as well as to the delicate and complicated machinery which operates the guns, would indicate that overhead protection against such fragments should be provided in order to insure the most effective operation of the coast armament.

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## EXTRACTS FROM THE 1914 REPORT OF THE CHIEF OF ORDNANCE, UNITED STATES ARMY

### GUNS AND MORTARS

*Erosion.*—A number of 10-inch and 12-inch guns which had reached the limit of their accuracy life from erosion were withdrawn from service and restored to satisfactory condition by boring them out and adding a lining tube. With a view to developing a steel that would be more resistant to erosion than the types now in use, a series of firings were made, using small-arms barrels of various compositions. In order to determine whether it had any direct relation to resistance to erosion the melting point of each of the steels concerned was carefully determined. The results have not been conclusive, but tend to indicate that the gun steel now in use is more resistant to erosion than are any of the alloy steels.

*Gun Construction.*—The wire-wrapped type of construction employed for all Army guns and mortars of 6-inch caliber and greater has continued to give excellent satisfaction, both as regards cost and efficiency.

*Completion and test of 14-inch guns.*—During the past year there have been completed and successfully tested a number of 14-inch guns of greater length and power than those of the type referred to in my last annual report. Some of the newer type are to be mounted in the turrets to be erected as a part of the defenses of Manila Bay, and others in the defenses of the Panama Canal. These guns fire a 1660-pound projectile, with a muzzle velocity of 2250 feet per second. The maximum range is about 18,000 yards, or slightly more than 10 miles. The theoretical penetration, in best-quality armor, with normal impact, is 20.5 inches at the muzzle and 11.2 inches at 15,000 yards.

*Twelve-inch mortars, model of 1912.*—Twenty-three of the latest type of 12-inch mortars, model of 1912, were completed during the year and issued to the Panama Canal fortifications. These are more powerful than those of the earlier type and have a maximum range of slightly more than 11 miles.

### SMOKELESS POWDFR

*Improvements in smokeless powder.*—The Joint Army and Navy Board on Smokeless Powder, consisting of officers of this department and of the Navy Bureau of Ordnance, has continued its work during the year, with a view to improving the quality and reducing the cost of manufacture of smokeless powder. No important change has been made in the specifications during the year, although a few changes of minor importance have been adopted in accordance with the recommendations of the board. The department has given increased attention to investigation and tests, with a view to improving the ballistic uniformity of the service smokeless powder and determining the cause of the high pressures that have occasionally occurred at the proving ground and at service target practice.

*Plant for reworking smokeless powder.*—There has been installed at the Picatinny Arsenal and put into successful operation a plant which will enable the department to rework into new smokeless powder any which has become so old as to be unsatisfactory for continued storage. The operation involves grinding up the old powder while immersed in water, repurifying the guncotton thus obtained, and remaking it into new powder by the usual process. This work can be done at about one-half the cost of new powder. There is good reason to believe that the quality of the product thus secured is equal to that of powder manufactured entirely from new material.

### AMMUNITION FOR CANNON

*Reserve ammunition.*—The supply of reserve ammunition for seacoast guns has been systematically gone over with a view to insuring that all necessary components constituting complete rounds are on hand at fortifications as contemplated, and that all such ammunition held at ordnance establishments is in condition for immediate issue as complete rounds. The most important change from past policy in this respect is in putting up into charges the powder to be held at ordnance establishments instead of storing it in bulk.

*Cartons for bursting charges.*—With a view to facilitating the addition of bursting charges to seacoast projectiles there has been developed a system of papier-mâché cartons into which the high explosive can be compressed and readily loaded into the projectile. Any space remaining around the carton is filled by the addition of paraffin. On account of the cost of the cartons and the expense of filling them, it is probable that they will not be used except possibly for bursting charges of projectiles to be retained in store at ordnance establishments for forwarding to fortifications when needed.

*Projectiles.*—There are under manufacture, or about to be ordered, from funds under current appropriations, sufficient long-pointed caps for equipping all the armor-piercing projectiles on hand in the insular possessions and on the Pacific coast of continental United States. These caps, by lessening the air resistance in flight, serve to keep up the velocity, and thus increase the extreme range and the armor penetration of projectiles.

*Shrapnel for land defense guns.*—During the past year a supply of shrapnel has been manufactured and issued for use in the 6-inch seacoast guns assigned to land defense purposes. A supply for the 4.72-inch and 5-inch seacoast guns assigned to such work was provided by overhauling and refusing shrapnel already on hand.

*Modernizing fuses.*—The work of modernizing all seacoast detonating fuses has been practically brought to completion, leaving no type in service which is not substantially equal to the latest.

### COAST ARTILLERY PRACTICE

*Behavior of matériel.*—Target practice reports received during the year indicate generally satisfactory behavior of the ordnance matériel used in this work. There were indications that three or four unexpectedly high pressures were encountered in the firings, but none of these seriously damaged the gun or mount. Investigation as to the probable cause is in progress. Continued study is being made with a view to determining the cause of such variations in muzzle velocity as ordinarily occur at target practice. These investigations include the effect of temperature of storage, absorption of moisture in blending, method of ignition, and a number of other features.

*Broad-banded projectiles.*—The general use of broad-banded projectiles in service has continued to prolong the accuracy life of worn cannon, as was predicted from proving-ground results.

*Increased ranges for seacoast guns.*—In view of a tendency to the use of increased ranges from ships' guns, firings have recently been made from a 12-inch seacoast gun, using a reduced weight of projectile, with a view to increasing the maximum range of the gun. The projectiles employed in these firings were the standard 700-pound long-pointed type used with mortars. A range of slightly more than 20,000 yards was thus secured from a service 12-inch gun mounted on a service barbette carriage. This result indicates that increased ranges, up to any reasonable limit, can readily be secured by supplying lighter-weight projectiles. This, however, necessarily involves the disadvantage of reduction in the weight of the bursting charge or in the strength of the projectile for armor penetration.

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## EXTRACTS FROM THE 1914 REPORT OF THE BOARD OF ORDNANCE AND FORTIFICATION

### MEANS FOR PREVENTING EROSION OF GUNS

In January, 1908, the board made an allotment for conducting test of a method of preventing erosion proposed by Mr. J. H. Brown. Experiments were continued under varying programs and additional allotments, as set forth in previous reports, until this spring, when the tests were finally completed. Mr. Brown has, however, asked that no conclusions be drawn from the tests until he shall have had an opportunity to analyze the results. The board has granted his request, so the matter is still pending.

### RANGE-POSTING DEVICE

July 2, 1912, an allotment of $225 was made for the construction and installation of three forms of range-posting devices proposed by the Coast Artillery Board for rapid-fire batteries. The tests resulted in the adoption as a type of one form of the device for installation in all batteries where practicable.

### LEON DEVICE FOR SUBMARINE MINES

On July 11, 1913, an allotment of $3600 was made for the construction and test of submarine mines containing the Leon device for automatically controlling the depth of submergence. Tests were first undertaken at the torpedo depot at Fort Totten for the purpose of perfecting the operation of the device and will be continued at points where the depth of water and currents will determine the value of the device under service conditions.

### RADIO CONTROL OF TORPEDOES

The Radio Engineering Co. early in 1913 presented to the board a proposition for test at their own expense of an apparatus for the radio control of submarine torpedoes. To permit of tests being carried on at night the board made an allotment on May 1, 1913, of $350 for the installation of a searchlight at the company's laboratory. The company has not yet announced its readiness to conduct formal tests of the apparatus.

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## EXTRACTS FROM THE 1914 REPORT OF THE CHIEF OF THE BUREAU OF ORDNANCE, UNITED STATES NAVY DEPARTMENT

### GUNS

The 5-inch cartridge-case guns of the *Florida* and *Utah* have been replaced by bag guns, and the 5-inch batteries of the *Arkansas* and *Wyoming* will be replaced during the next overhaul period of these vessels. This will give all vessels of the *Utah* class and later date the same type of torpedo-defense guns.

### PROJECTILES

Preliminary steps have been taken by the bureau toward the acquisition of a foreign system for the manufacture of projectiles, should the efficacy of such a system be demonstrated to the satisfaction of the bureau.

The bureau is still more than ever inclined to the opinion that the best possible type of projectiles for the attack of armored vessels is the armor-piercing projectile, carrying sufficient explosive to detonate and fragment the projectile after having passed through armor; and it is thought that the penetrative power of projectiles has been increased to such an extent as to insure a satisfactory percentage of success.

Experimental firings have been conducted at the proving ground with projectiles of foreign manufacture and with projectiles of various shapes, in order to ascertain the relative qualities of each. In order to ascertain what progress has been made in the quality of armor-piercing shell there were recently fired at Indian-head armor-piercing shell manufactured in 1903, which at that time were extraordinarily efficient. These shell were fired at the same plate in competition with the highest grade of shell of recent manufacture, and it was found that the shell being produced to-day possess great superiority over those considered the best 11 years ago. Inasmuch as the sole measure of the efficiency of armor is furnished by its test with armor-piercing shell, these experiments are an important witness to a like advance in the quality of the armor now being furnished.

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## LIGHT GUNS OF LARGE BORE AND HIGH-EXPLOSIVE SHELLS

By George Quick, Fleet Engineer (R.N.), Retired

In the *Times* of the 23rd inst. the military correspondent states:—"It is odd how little was known about the heavy guns. Even when the writer some weeks ago described the heaviest German field howitzer known to him—namely, the 11.2-inch—a technical paper called *Arms and Explosives* expressed its frank disbelief in the existence of such a weapon; and after various sarcastic remarks, and much admirable reasoning of a techincal kind, rejected the howitzer altogether, and declared that the writer's statement must be dismissed as an unnecessary attack on the confidence of our troops."

Having had the honor of giving a lecture on April 22, 1891, at the Royal United Service Institution, Whitehall, on "Heavy Guns *versus* Light Guns," I hope you will kindly publish a few short extracts from that paper, in which the superior efficiency, economy, and safety from the enemy's fire of heavy ordnance were clearly shown.

First, as regards safety. I showed that guns of various calibers would expose the following areas of surface as a target for the enemy's projectiles:

| | Area in Square Feet. |
|---|---|
| 1000 tons of 16.25-inch guns | 590 |
| 1000 " 13.5-inch " | 716 |

| | Area in Square Feet. |
|---|---|
| 1000 tons of 12-inch guns | 730 |
| 1000 " 9.2-inch " | 982 |
| 1000 " 8-inch " | 1200 |
| 1000 " 6-inch " | 1650 |

This indicates that any given weight of 16.25-inch guns would offer half the target surface of an equal weight of 8-inch guns.

I then discussed the effects of shells when firing against vessels in harbor, batteries, dockyards, or public works, and stated that: "If the structure be not completely perforated, only very trifling damage can be done by small shells." As the result of many experiments at home and abroad, I showed that the relative destructive effect of the shells of that period would be approximately as follows:

| | Destructive Effect. |
|---|---|
| 6-inch shell | 1.00 |
| 8-inch " | 3.25 |
| 9.2-inch " | 6.00 |
| 12-inch " | 17.80 |
| 13.5-inch " | 121.40 |
| 16.25-inch " | 572.00 |

I showed also the absolute economy in the money cost of the heavy shell as regards mere weight per pound, economy in transport, and particularly in the money cost for the damage inflicted on the enemy by, say, 1000 tons of shells.

Now that our recently purchased light-draught vessels are bombarding Ostend, I quote the following words from the same lecture: "I hope it will be remembered that our vessels must not only be able to meet those of the enemy, but that our vessels should be able effectually to attack an enemy's ports and seaboard at long range." I have consistently advocated the principle of *special ships for special purposes*, and therefore I have been in favor of a special class of vessels for coast and harbor defense, because those vessels best adapted for harbor defense are the very best for the attack of enemy harbors. Such vessels would be very economical in first cost and in upkeep, and could be efficiently manned by small crews of local naval volunteers and veteran naval reservists.

Such vessels would be of infinite value in attacking enemy harbors at long range and in defending our shores in case of the defeat of our High Seas Feets by a coalition of hostile naval Powers, which latter is not an impossible eventuality in the near future, although very improbable apparently at the present moment. However remote such a disaster may appear at present, it ought to be provided against as soon as possible. The large majority of naval experts were opposed to this system of coast attack and defense; but I believe Earl Brassey, the veteran naval reformer, held this view many years ago, when I had some correspondence with him on naval matters.

In the discussion following my lecture in 1891 I proposed battleships of 20,000 tons to carry 15-inch guns, and on June 1, 1895, four years afterwards, I wrote to the Admiralty to suggest once more the adoption of 15-inch guns. We have some afloat now. My proposals of April, 1891, attracted considerable attention abroad, and I received an invitation from the United States War Department to contribute a paper to the Division of Military Engineering of the International Congress of Engineers at Chicago in 1893. I sent a paper on "Heavy Guns and High-Explosive Shells," which was accepted and subsequently published in the official report, issued at Washington in 1894. Recent events in Belgium and France induce me to quote that which I wrote twenty-one years ago: "Some English writers on the future of naval warfare have expressed the opinion that ships will never again attack coast fortifications, and that humanity will prevent the bombardment of unprotected seaports. Continental writers on this subject have expressed an opposite opinion, and have stated that future wars will be wars of extermination, in which undefended towns and private property will be ruthlessly destroyed to cripple the enemy as much as possible whenever the opportunity offers. The writer reiterates his conviction (one of many years' standing) that victory will attend on the guns of large bore and on the shells of great explosive power." That forecast has been completely fulfilled by recent events. The experience of some notable sieges during the last sixty years—Silistria, Kars, Sebastopol, Metz, Strasbourg, Paris, Plevna, Pekin, and Ladysmith—proves how little damage was done by large numbers of shells not exceeding 8-inches in diameter. More recent experience in Belgium and France fairly proves the accuracy of the statement I wrote in 1893, that the relative destructive effect per pound of cost of various shells of the same kind, but of various diameters, would be approximately as follows (for every pound expended):

| | | | Destructive Effect. |
|---|---|---|---|
| 1*l.* | expended on | 12-inch shells | 480 |
| 1*l.* | " | 9.2-inch " | 294 |
| 1*l.* | " | 8-inch " | 254 |
| 1*l.* | " | 6-inch " | 62 |

That paper, written in 1893, contained a proposal which, I believe, preceded by several years Colonel Cuniberti's proposal for the battleships now known as "Dreadnoughts." I quote verbatim from the Official Report, published at Washington in 1894: "There can be no doubt that a ship of 14,000 to 16,000 tons can carry four turrets, each turret having two 32-cm. guns (12.6-inch guns), the turrets being arranged so that the eight guns can be fired on either broadside, or six of the guns could be fired ahead or astern. Such a ship would carry an auxiliary armament of small quick-firing guns to destroy torpedoboats, etc., and on the top of each turret two 15-cm. quick-firing guns could be mounted in a shield or small turret, which could be rotated independently of the large turret. Such a ship will surpass in fighting power, and in the safety of its armament, every ship now afloat; the separation of the guns in four independent turrets being of importance to prevent total disablement and to maintain, if necessary, great rapidity of fire on both sides of the ship at the commencement of an engagement at sea."

I think it must be generally admitted that my former proposals have been practically adopted, and I now submit that new weapons as destructive as the largest howitzers of the Germans can be constructed of very light weight, so that they could be transported through swamps, and over sandy plains and mountain passes with much ease and rapidity and at little expense of horse or motor-power; and also carried in coast attack vessels and river boats of very small draught.

It would not be prudent to say more on the proposed weapons, as I do not desire them to be evolved by our most scientific and enterprising antagonists.

In conclusion, I must express the wish that we may soon have some specially-designed vessels for coast attack, to carry guns of very great caliber, but of comparatively light weight.—*Engineering.*

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## GUN-PRIMERS AND DETONATORS

A recent issue of the Italian *Rivista di Artiglieria e Genio* contains an article on gun-firing, which was written both to demonstrate the advantage there is in the use of black powder, instead of smokeless powder, for charging primers, and to put on record the work of various experts in regard to the manufacture of primers—an item which has acquired special importance since the adoption of smokeless powders.

The explosives which deflagrate when they are lighted by a match in the open in small quantities, such, for example, as dynamite, nitrocellulose, the ammonium nitrate explosives, and, in general, all the nitrated explosives, whether pure or mixed, require the use of a primer to develop their power. The explosives, on the other hand, which explode in contact with a flame, such as fulminate of mercury, nitride of lead, black powder, Berthollet powder (a potassium chlorate powder), only require a simple firing medium, such as a quick-match, a slow-match, a friction-tube, or a metallic cap containing a substance which can be set alight by shock or by an electric spark.

Priming at first resolved itself into the placing of powder in the pan; this powder was set alight by the flint, and it fired the charge. The present-day primer, due to the use of smokeless powders, has a different function, and may be considered as a device for governing the intensity of the initial shock and as a means to secure the complete explosion or detonation of the powder charge. There is therefore an intimate connection between modern explosives, the primers, and the substances contained in the latter.

Gun-primers consist of a copper or brass cap filled with a mixture capable of being ignited by a shock, and of a priming charge; this may be black powder or smokeless powder, and it causes the gun-charge to explode. According as black powder or smokeless powder is selected for the priming charge, the function of the cap varies, since black powder behaves quite differently from smokeless powder. The experiments carried out by Roux and Sarrau showed that most explosives, nitroglycerin, nitrocellulose, picric acid, etc., explode or detonate according to the method in which they have been treated, and that black powder, which is commonly granulated, always explodes, both under the action of a match or under that of a cap of fulminate of mercury; it can be made to detonate only with a primer of fulminate and nitroglycerin, and by detonating its effects are considerably increased.

At this point, the author of the article, Mr. Guido Finzi, Chief Chemist of the Italian Corps of Artillery and Engineers, explains the meaning of the terms "deflagration," "explosion," and "detonation." A deflagration is a sharp reaction accompanied by a flame and a strong concussion; it is produced when a small amount of explosive, such as guncotton, ballistite, etc., is fired in the open by a flame. An explosion is a violent reaction accompanied by a flame, and a sharp noise; it occurs when black powders, or when smokeless powders, are placed in a closed receptacle, or between partitions which can give way, and are lighted by a slow-match, a quick-match, or a flame. A detonation is the most violent explosion which can be obtained with a given explosive; it occurs when adding to the lighting medium—flame or electric spark—a suitable primer. Some experts, he adds, call a detonation an explosion of the first degree, and an explosion one of the second degree.

When using black powder for charging the primer, for exploding which a flame is sufficient, the function of the fulminating cap is reduced to that of a simple igniting agent. If, on the other hand, the priming charge consists of smokeless powder, for which a simple igniting agent is not sufficient, the function of the cap is that of a real primer, which has to cause the explosion of the priming charge, which latter, in this instance, transmits and multiplies the effects produced by the cap. The quality and the quantity of the fulminating mixture in the cap are of great importance when the charge in the primer is smokeless powder, since, if the fulminating composition is too weak, it will only promote the deflagration of the charge in the primer; if too violent, it will promote its detonation, and it has to be so regulated as to promote the entire explosion of the charge, a condition which is difficult to obtain in practice.

The explosion of the gun-charge is produced by the shock and the pressure which the products developed by the decomposition of the priming charge exert against it. The shock is due to the dynamic energy, or *vis viva*, which animates the new products formed, and is represented by the well-known formula, $\frac{1}{2} m v^2$, where $m$ is the mass of the new products, and $v$ their velocity. The pressure is a static phenomenon due to the volume of the gases developed and to the great rise in temperature. In his *étude* on explosives, published in the *Moniteur Scientifique* for November, 1906, Bickel demonstrated that the effects produced by an explosion—*i.e.*, the shock and pressure above referred to—do not act at one and the same time, there being between the two phases of the phenomenon an interval of 5/100 second; the shock effect acts first, followed by the pressure effect. The charge in the primer being small, and the space in the powder-chamber of the gun being comparatively large, the effects of the primer due to the pressure, which has a tendency to decrease by loss of heat through the gases coming in contact with cold surfaces, may be considered very limited, if not nil, and the explosion of the gun-charge is due solely to the shock effects. The decomposition of the charge in the primer gives rise to new bodies of varied specific gravity, which transmit to the gun-charge shocks of more or less intensity, the component shock being the one represented by the above formula.

The smokeless powders are transformed into gases and vapors, whilst black powder is transformed into gas and solid bodies. The solid bodies formed on the explosion of black powder—potassium carbonate, potassium monosulphide, and potassium sulphate—amount to 57 per cent of the products of the decomposition, and have a specific gravity much above that of the gases and vapors formed on the explosion of smokeless powders. With primers charged with black powder there is therefore obtained (*a*) a more uniform firing of the gun-charge, and the avoidance, at the same time, of the risk of causing it to detonate or to explode incompletely; (*b*) the shock for exploding the gun-charge gives rise to much lower pressures and temperatures, and the risk of deforming the primer-case is decreased, thus eliminating the difficulty of unscrewing it after the round is fired, a difficulty which is encountered with most of the primers when primed with a smokeless powder; and (*c*) the possibility of reducing to a minimum the strength of the fulminating mixture in the cap, this acting as a simple igniting device.

Detonators are the very powerful primers used for firing the charge of bursting shells, mines, etc. Until quite recently, fulminate of mercury has been used exclusively for priming. This substance, whatever means be taken to promote its decomposition, detonates, both in a closed space or in the open, with such violence that, presumably, it decomposes before the new products formed, a part of which have a high specific gravity, have had time to dilate. By detonating, it produces a shock capable of causing the explosion or detonation, not only of guncotton, dynamite, etc., but also of bodies which, although they had been known for a long time, had hitherto been considered inert substances, such, for example, as trinitrophenol, one of the most potent explosives of modern times. The maximum charge in detonators does not exceed two grammes. When this charge is not sufficient to obtain the required result, such, for example, as with large explosive shells, it is necessary to add to the detonators an intensifying medium, which is proportioned to the quantity of explosive to be detonated. This medium consisted, at first, of dry cotton-powder, which, later on, was replaced by picric acid, as this is practically insensible to shocks; picric acid is being, in its turn, replaced by trinitrotoluol, also called trotyle, trilite, and tolite, because this substance, while it has the quality of picric acid, also has the advantage of not giving rise to the formation of compounds of a similar nature to picrates, which are dangerous, owing to their great sensibility to shocks. The velocity of detonation of fulminate of mercury and of trotyle varies, according to different experimentalists, between 6500 and 7200 meters per second. The velocity of decomposition of ordinary explosives is much lower; it does not exceed generally 3000 meters. That of gelatine, for example, is of about 2000 meters per second.

Fulminate of mercury is now being replaced for priming detonators by a new substance, a derivative of hydronitric acid ($HN_3$), improperly called nitride of lead, the chemical formula of which is $PbN_6$. Its sensibility to shocks may be considered equal to that of fulminate of mercury. On exploding it gives out an amount of gases less than does fulminate of mercury, but has a velocity of decomposition greater than the velocity of decomposition of fulminate. Its feature is that it detonates even when damp. Germany is studying the application of this substance for use in land warfare; detonators charged with nitride of lead are available in France and Germany for mines.

—*Engineering*.

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## ATTACKS ON THE COAST LINE BY BOMBARDMENT, BY AIRCRAFT, AND BY SUBMARINE

### THE EAST COAST RAID

On the morning of Wednesday, the 11th [December], a strong force of German ships, consisting apparently of five battle-cruisers and two armored cruisers, appeared off the Yorkshire coast, having slipped across the North Sea under cover of darkness and mist. At 8:15 a.m. three of the ships, two battle-cruisers and an armored cruiser, opened fire on Hartlepool and West Hartlepool. Our land batteries replied with, apparently, some effect. At ten minutes to nine the bombardment ceased, and the enemy's ships steamed off. Thereafter they were apparently engaged ineffectively by some British patrol vessels, among which were the "E" or "River" class destroyer *Doon*, the "K" class destroyer *Hardy* and the light cruiser, *Patrol*, a sister ship of the ill-fated *Pathfinder*. These vessels suffered casualties amounting to seven killed and thirty wounded. The damage inflicted on the Hartlepools was very extensive. A fairly full account of it, from our North of England correspondent, appeared in last week's issue. The death roll among the inhabitants, according to the latest available information, amounts to 106, while between four and five hundred persons were injured. Seven soldiers were killed and fourteen wounded. Simultaneously, a battle-cruiser and an armored cruiser fired fifty rounds or so into Scarborough. The damage to property was great, but fortunately the casualties were smaller. These to date amount to eighteen killed and about a hundred injured. Two battle-cruisers also bombarded Whitby, doing considerable damage. The death roll here now amounts to three, while half a dozen people were injured. Payment for damage to property and compensation for the loss of life and injuries inflicted on the civil population is to be made out of the nation's purse. The correct view to take of this, in many aspects, brutal raid, is undoubtedly the official one, namely, that in itself it has no military significance. The facts so far known to us seem to point the moral of a yet stronger Navy, one strong enough, that is, to deal with such minor operations as this without deflecting any portion of the requisite strength from strategically important stations.—*The Engineer.*

### THE CUXHAVEN AIR RAID

Whatever military value it may have—and we believe that to be considerable—the technical interest of the British seaplane raid on Cuxhaven is so great that we have no hesitation in speaking of this feat as the most important aeronautical achievement of the war so far. Let us first record briefly what happened. Last Friday, Christmas Day, seven naval seaplanes were taken to a point near Heligoland. Presumably they were transported there. They were provided with an escort consisting of the new light cruisers *Undaunted* and *Arethusa*, together with a force of destroyers and submarines. At daybreak the seven seaplanes set off on a journey of about forty miles to the Schillig Roads, Cuxhaven, where they delivered bombs on the German warships there assembled, and on certain points of military significance. Meanwhile, the ships of the escort had been observed from Heligoland by the enemy. Strangely enough, perhaps wisely, no surface vessel was sent against them. Instead, two Zeppelins, three or four seaplanes and several submarines were despatched to the attack. Then ensued a battle in three planes. Our submarines, apparently, took no combative part in the action, but our cruisers and destroyers were attacked by the torpedoes of the enemy's submarines and by bombs from his seaplanes and dirigible balloons. By rapid maneuvering and by the activity of our destroyers, the submarine torpedo attacks were frustrated. The bombs from the hostile seaplanes did no damage whatever, although some seem to have fallen fairly close to our ships. As for the Zeppelins, these "were easily put to flight by the guns of the *Undaunted* and *Arethusa*." For three hours our ships remained off the enemy's coast, with, we presume, the seaplane mother ships somewhere in the background. At the end of this time three of the raiding aviators had returned. They, with their machines, were safely taken on board, and the fleet steamed away. Our submarines remained behind or waited elsewhere, as had been arranged, and picked up three others of the pilots who returned later. The seventh pilot, Flight-Commander F. E. T. Hewlett, R.N., is still missing. His machine was observed in a wrecked condition about eight miles from Heligoland. As the submarines could not hope to tow the three seaplanes, the machines were sunk to prevent the enemy benefiting by their capture. The presence of fog considerably hampered and assisted both sides in the engagement.—*The Engineer.*

### A SUBMARINE EXPLOIT

On Sunday, the 13th [December], the British submarine *B11*, under the command of Lieutenant-Commander N. D. Holbrook, penetrated half-way up the Dardanelles and torpedoed and sank the Turkish battleship *Messudiyeh.* The exploit was carried out in face of a difficult current and involved diving under five rows of mines. On the return journey the submarine was pursued by gun fire and torpedoboats, and on one occasion had to remain submerged for nine hours. Lieutenant-Commander Holbrook has since been awarded the Victoria Cross, the first naval recipient of the honor in the war. The *Messudiyeh* was forty years old, having been built at Blackwall in 1874. She was reconstructed at Genoa in 1902. Her main armament consisted of two 9.2-inch and twelve 6-inch guns. Her guns were modern, as were her engines and boilers and portions of her armor. Her destruction is "of no military significance," but may well prove of considerable political importance, for in spite of her age she was quite an important element of the Turkish navy. Her destroyer, the *B11*, dates from 1905, and compared with our latest "E" and "F" classes of submarines, is quite a small vessel, a fact probably in her favor in her daring enterprise. She has a surface displacement of 280 tons, and with 600 and 200 horse-power respectively travels at a maximum of 13 and 8 knots on the surface and when submerged. She carries two torpedo tubes. A great deal too much was, in our opinion, made of the exploit in the London daily Press. The occurrence possesses certain aspects of technical interest. But beyond that, while recognizing and admiring the daring displayed by the commander and crew of the submarine, we hesitate to go.—*The Engineer.*

### SUBMARINES AND MINE-FIELDS

Although the exploit of *B11* in sinking a Turkish battleship in the Dardanelles, was at the time it took place, easily the most brilliant naval feat of the war, it did not, as some people appear to think, stand alone as a case where a submarine had worked its way through a mine-field. What made the achievement of *B11* so splendid was the fact that she wormed her course between no less than five closely sown lines of mines, almost dragging herself along the bottom, in a spot where the cross-currents, eddies and whirlpools made it almost inevitable that she would be swept foul of the moorings of the mines and cause them to explode and destroy her. To pass through this mine-field twice without harm was a supremely daring piece of seamanship, apart from hiding on the bottom and dodging her pursuers for the greater part of the time. It deserves and will probably receive special recognition. Since the war opened, the days and nights have been so crowded with such exciting events, that our memories are overwhelmed and confused and we forget. In the despatches relating to the Battle of the Bight, however, Commodore Keyes reported that on one occasion submarine *E6*, commanded by Lieutenant-Commander C. B. Talbot, actually fouled a mine and brought it to the surface, where it was cleared, and left the boat unharmed, by the skill and daring of Lieutenant F. A. P. Williams-Freeman and Able Seaman Randal Curner, who both received special reward for their heroic piece of work. *E6* and other boats passed under a German mine-field and German boats have passed under our mine-fields in the North Sea and Straits of Dover.—*United Service Gazette.*

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## EXTRACTS FROM THE BIMONTHLY ORDNANCE REPORT

### For November-December, 1914

#### WATERVLIET ARSENAL

*New 15-pdr. breech mechanism.*—New breech mechanisms for fifty-nine 3-inch (15-pdr.) guns, model 1902, were manufactured and attached.

### For January-February, 1915

#### THE ORDNANCE BOARD

*Saluting gun, model of 1912.*—Test not satisfactory. Type of gun with vertical sliding block and having the breech open at top to facilitate loading, recommended.

*.22 caliber ammunition for subcaliber practice.*—Tested in subcaliber barrels in 3-inch field gun, 3-inch seacoast gun and 3-inch mountain howitzer. Results satisfactory. Firing springs of proper strength, made at the Proving Ground, were established during the test.

*Reliability of base detonating and base percussion fuses turned in from service.*—Fuses received from the Southern Armament District all satisfactory, including base detonating fuses issued between two and five years and one lot of base percussion fuses seventeen years in store at Key West.

#### FRANKFORD ARSENAL

*Focusing caps for telescopic sights.*—An order has been received for the manufacture of focusing caps, 11 for 3-inch telescopic sight, model of 1912, and 45 for 3-inch telescopic sight, model of 1904. These caps will permit of focusing the telescopes at a distance of 25 feet.

*Experimental plotting board.*—An order has been received for the manufacture of one experimental plotting board. This board is a modification of the design of the 120-degree mortar plotting board to incorporate changes suggested by the Coast Artillery Board after test.

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## SECONDARY ARMAMENTS

It has been stated in the lay Press that men who took part in the recent North Sea fight have declared that the heavy ships were never nearer to each other than eight miles. Such reports are scarcely to be relied upon, but if they be true in this case it means that under the light of the experience gained in the first battle between "Dreadnoughts," Great Britain may once more be inclined to change her plan for arming her heaviest vessels. When Sir John Fisher, as he then was, brought the first "Dreadnought" battleship and the first three battle-cruisers into existence, he did not give them a secondary armament, nor did many of their successors have anything but 12-pounders and 4-inch guns with which to resist torpedo attack and join in peppering the enemy at short range. Persistent advocacy, however. since Lord Fisher's retirement, on the part of those who believed in secondary armaments (and we confess that we were among them) succeeded in getting 6-inch guns placed on board our latest super-"Dreadnoughts." But the meeting of the battle-cruisers the other day, and the distance at which the battle was fought, has given us all cause to think furiously, and we have to ask ourselves if, after all, Lord Fisher's instincts were not right at the outset in giving all the tonnage to the two prime factors of heavy armament and speed. Six-inch secondary batteries meant sacrifices in heavy guns, speed, fuel, or ammunition, all of which recent experience has shown are of more consequence than a six-inch battery in a battleship or battle-cruiser fight.

The sea fights of this war have generally taken place at, or near, the extreme range of the heaviest guns on either side, and the victory has gone to the side with the most guns of the largest caliber, or the longest range. Even in the battle off the coast of Chile, ships with 6-inch guns on board had but little chance to use them. In the battle off the Falklands Admiral Sturdee sunk the two largest of his opponent's vessels with his two battle-cruisers, neither of which carried 6-inch guns. If the last of the North Sea battles was fought at a distance of over eight miles, it was the primary gun that settled the business. and as experience has now shown that long-range fights will be the rule, only to be broken in exceptional circumstances, then the tonnage of our bigger ships will be better employed in carrying more heavy guns, or in providing extra speed, than in carrying secondary batteries of 6-inch guns for these "exceptional" cases. During the whole of this war, so far as we have been told, the enemy has only once attempted to attack our heavy squadrons in the North Sea or Adriatic, by surface torpedo craft. This was during the last battle and the torpedo craft were then driven off by our 12-inch gun fire. It is now recognized that such attacks could only succeed under the most favorable circumstances. The best defense, also, of heavy craft against submarine attack, is now allowed, by common consent, to be a vigilant destroyer patrol. Hence, if secondary armaments are not needed to beat off surface or underwater torpedo craft attack, and can rarely be used in contests between heavy ships, on account of long-range fights being the rule, then it is a question if they are needed at all, and if the flotation they absorb cannot be put to better use.—*United Service Gazette.*

# BOOK REVIEWS

*Napoleon at Work.* By Colonel Vachée. Translated from the French with a foreword by G. Frederic Lees. London: Adam and Charles Black. New York: The Macmillan Company, 66 Fifth Ave. 6" x 8¾". 324 pp. Two maps of the Imperial epoch and one sketch-map; also frontispiece of Napoleon I and his staff, after the picture by Meissonier. 1914. Cloth. Price, $2.00 net.

The object of this work, one is told in the author's introduction, is not learned analysis of the plans for Napoleon's campaigns and battles, but "it is the man himself, in thought and action, that we would depict from life"; and the object has been so thoroughly accomplished by the author and its accomplishment so well preserved by the translator that, when one lays the book down, it is with a feeling of regret at parting company with the man Napoleon. However, the word "regret" leads one to reflect that the feelings of the reader, from his point of vantage outside the book, may be wholly different, on this occasion of parting, from what they would have been had the reader been one of the characters inside the book.

Indeed, over and above the testimony given by Napoleon himself as to the relief the world in general would experience at his demise, that the lives of those about him were not happy, is indicated by the words of the Chief of the Staff, Berthier, when found by Méneval, "his head buried in his hands and his elbows on the table": "'What is the good,' he said, 'of having given me an income of one million five hundred thousand francs, a fine house in Paris and a magnificent estate, to inflict upon me the tortures of Tantalus? I am being killed here with hard work. A mere soldier is happier than I am!'"

In ten chapters the author presents his picture of Napoleon at work: Thought and Decision; Execution (2 chapters); The Emperor's Household: The Staff; Superintendence of Execution; Distribution of Rewards and Penalties—Napoleon and his Generals; Distribution of Rewards and Penalties—Napoleon and his Soldiers; On the Eve of the Fight; The Battle. And in reviewing it, the temptation is great to transcribe the whole; but effort will ne made to convey an impression of the excellence of the work by limited quotation and reference.

The author gives as the obligations of command: intellectual work; arrival at a decision; superintendence of its execution; and the distribution of rewards and penalties.

Of Napoleon's method of intellectual work, we are told: "On campaign, on the eve of battle, night was specially devoted to his intellectual work. Having generally retired to rest about eight o'clock, after dinner, he rose at the moment the reports on the reconnaissances reached imperial headquarters, that is, about one or two in the morning. Baclcr d'Albe had spread out for him on a large table in the room which served as a study the best map of the seat of the war. On this map, set very accurately to the compass and surrounded by twenty to thirty candles, were marked with pins with colored heads the various positions of the army corps and, as far as they were known, those of the enemy. It was on this that he worked, moving his compasses, open to the scale of six to seven leagues—a march—here and there. Before the night was over he had made up his mind, and dictated and despatched his orders, which the troops carried out at break of day." Of his manner of planning, Napoleon himself said: "No man is more pusillanimous than I am when I draw up a military plan. I exaggerate every danger and every evil possible under the circumstances. I am in quite a painful state of agitation. That does not prevent me appearing very calm before those who surround me. I am like a woman in travail. But when I have come to a resolution everything is forgotten, except that which may lead to its attainment." In a letter to Lauriston, Napoleon gave three of the principles that directed him in planning and in executing: "Always remember these three things," he said, "concentration of forces, activity, and a firm determination to perish with glory."

Of the disadvantages to subordinates of the Napoleonic method of execution, as compared with the modern technique of field orders, etc., we get an idea from the following: "In short, these orders, although verbose, contained little: the object of the march, the position of the army, and, in the case of the corps in the front line, instructions to obtain information concerning the enemy. But as to what the general-in-chief himself knew about the enemy, as to the ensemble of the projected maneuver and the mission of each corps in that maneuver, there is no mention." Concerning lack of instructions as to roads to be followed, Davout wrote to the Chief of the Staff: "I have the honor to beg Your Excellency kindly to fix the roads we ought to take, in order to avoid the very serious difficulties arising from passing such large army corps through defiles of this nature, and those which may arise as regards provisions." And to add to the difficulties of subordinate commanders, "the Emberor was at that time regarded by all who surrounded him as an infallible being, and no one would have taken the responsibility of drawing his attention to even an evident error."

But the errors of the Napoleonic system of execution through subordinates, were, when the great master was in his prime, more than made up for by his superintendence of execution. "An order given is not an order executed; between the two there is the whole distance which separates the word from the deed, and like a true man of action the Emperor was careful to see that, in his army, there was no confusion on that point. To verify the execution of orders given is one of the greatest obligations of a commander." To Ségur, who had made a report of an inspection, Napoleon, then First Consul, said: "I have seen all your reports on armaments; they are correct. However, you forgot two cannons at Ostend." "'He had ordered the placing of these two guns behind the town on an embankment in case of a surprise. The order had not been carried out.' Ségur left, overcome with astonishment at Napoleon's memory." And on the battlefield, as well as at his administrative headquarters, Napoleon superintended execution: "He wished to see things for himself, 'for a general who sees with the eyes of others will never be in a position to command an army as it ought to be commanded'; he was present at the fight * * * * There, indeed, as elsewhere, all intellectual activity was concentrated in himself, leaving to others but the rôle of executants."

Of Napoleon's practice in bestowing rewards an appreciation is gotten from the *Mémoires of Mme. de Rémusat:* "Whilst the Emperor knew how to stay his generals' pretensions with a firm hand, he spared no pains to encourage his soldiers." Of his object in repressing his generals, his remark concerning Davout is indicative: "Davout is a man to whom I can distribute glory without inconvenience; he will never know how to bear it." And of his method with his soldiers the following is an illustration: "At one of these distributions of military rewards, which resembled family scenes, a non-commissioned officer was pointed out to the Emperor as being the best and bravest. The colonel, whilst admitting that he possessed the necessary qualities to make a good officer, added that, in rendering him this justice, he regretted that he could not propose him because of a serious hindrance. 'What is it?' asked Napoleon, sharply. 'Sire, he can neither read nor write.' 'I make him an officer.' was the retort. 'Colonel, you will see that he is recognized in that quality.'" However: "Because unjustified choices were made fairly often, one must not conclude that the whole system of promotion was based on political, dynastic, or personal considerations; we must regard those cases merely as favors necessitated by the establishment of a new *régime.* This allowance having been made, we must recognize that the emperor strove to furnish his army with a sound complement of officers. It was necessary to remain for a fixed time in each rank before being proposed for promotion."

The importance which Napoleon attached to character as the chief requisite for an officer is well known. "He declared more than once that the primary quality of a man of war is firmness of character." "The mind, added Napoleon, taking a sailing ship as a means of comparison, is the sail, and character the draught of water. If the latter is considerable and the masts are weak, the vessel makes little progress, but it resists the violence of the waves; if, on the contrary the sails are strong and high and the draught of water small, the vessel can navigate in fine weather, but at the first storm it is submerged. To sail well the draught of water and the suit of sails must be in exact proportions." "'Men who do not possess much character but are highly intellectual are the least fitted for war: they are ships whose masts are disporportioned to their ballast; it is better to have a good deal of character and little intellect.'"

That, while the Napoleonic principles are to be followed, yet Napoleon's method of warfare is not to be adopted, Saint-Cyr teaches in the following words: "I have always thought that, if it often gave him a great advantage, it was the result of his character more than the method itself, which ever appeared to me, even at the time of his most brilliant victories, to be too hazardous to be followed by generals of less extraordinary temper."

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*Nozioni Fondamentali di Balistica Interna.* Second Edition. By Giovanni Bianchi, Tenente Colonnello di Artiglieria. Torino, Italy: Published under the management of G. Madaschi, Captain of Artillery, by Libreria Editrice Carlo Pasta, Piazza Castello, N. 22. 6½" x 9½". 256 pp. 1 plate of 7 figures. Paper. 1914. Price, 8 lire.

The work of Colonel Bianchi on ballistics and allied subjects is necessarily attracting increased attention as his position as an authority on the subjects of which he treats becomes more firmly established. The present work is founded on the method of Colonel Mata, of Madrid, and is clearly and completely developed. It assumes that the velocity of combustion varies directly with the pressure, a law which gives satisfactory results in practice, and which leads to working equations of suitable simplicity. It also assumes adiabatic expansion of the products of combustion, both during and subsequent to the burning of the powder, the indices of expansion depending upon the characteristics of the powder.

The following cases are treated:

(a) Powder completely burned before the projectile starts to move.

(b) Inflammation instantaneous; the projectile starts to move at the instant of inflammation, and the powder burns during the travel of the projectile.

(c) Inflammation instantaneous; a fraction of the powder charge is consumed before the projectile starts to move, the remainder burning during the travel of the projectile.

(d) Inflammation not instantaneous; a fraction of the powder charge is consumed before the projectile starts to move, the remainder burning during the travel of the projectile.

The ideas presented in (d) are bound to attract our attention at this time, on account of the effect they should have on gun design so as to facilitate the development of uniform muzzle velocities. Over twenty years ago Mr. Quick pointed out that rear ignition with powder of ordinary granulation would not give even suitable inflammation, let alone instantaneous inflammation; and, while making his principal argument a brief for a type of powder granulation developed by him, he stated that large powder chambers also would be of assistance.

The reason for this is not difficult to understand, when considered in the light of the present treatise. The larger the powder chamber, the lower the density of loading and the greater the fraction of the charge burned before the chamber pressure rises to the point required for starting the projectile. As inflammation is a function of time, the gain in time thus secured is of great importance; as, if the charge be wholly ignited before the projectile starts, the emission of gas will be more equally distributed throughout the chamber and the charge less violently agitated at this important period. As the velocity of combustion increases with the pressure, and as the pressure rises rapidly after the projectile starts, it at once appears that if inflammation be not completed before the projectile moves, considerable variation in the unconsumed web-thickness of the powder grains must be expected to occur during this period of combustion. If, on the other hand, the time required for the development of the chamber pressure necessary for starting the projectile be extended so as to permit of complete inflammation of the charge, the variation of the unconsumed web-thickness of the powder grains should be small, as, on account of the low pressure, the speed of burning will be low.

The four cases cited above are all clearly and completely treated, and by means of parameters of loading, and tables, the calculations for any given gun are greatly simplified. Special attention is given to the problem of determining the point of maximum pressure, by analytical methods, and the computations relating to it are simplified by means of tables of auxiliary functions.

Interesting chapters are devoted to the usual secondary problems, the determination of the constants used in the velocity and pressure formulæ, the application of the various formulæ to the study and design of artillery, and the methods and instruments used in experimental interior ballistics.

The presswork, paper and type are excellent, and the page pleasing to the eye. The binding is poor and the edges rough, but this is probably intentional, in order to keep down the cost of publication. The book can readily be rebound in as substantial a manner as desired.

It is an able book on a most important subject and is recommended for the study of those interested in the science.

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*Taschenbuch der Kriegsflotten. 1914-15.* By B. Weyer, Kapitanleutnant a.D. Munchen, Germany· J. F. Lehmann's Verlag. 4½" x 6½". Paper. 1914. Numerous illustrations. 1st Sup., 27 pp.; price, 50 pfennig. 2nd Sup., 91 pp.;price, M. 4.5.

There have recently been issued two supplements to the war issue of Weyer's Handbook of Navies, 1914 1915.

The first contains the changes—other than those for Austria and Germany—which took place in the world's navies from the beginning of the war up to December, 1914. The changes in the naval strength of Argentine, Brazil, Chile, Norway, and Turkey were caused by Great Britain's taking immediate possession of all ships under construction for those countries in her territory; and the change wrought in the British fleet by this measure, was the gain of nine ships, which was quite an asset. In addition to that, Great Britain increased construction activities on her own ships, so that three ships of the line were completed by December 1914; two more, and larger, ships were to be placed in commission in the beginning of 1915; and still two others, later in the spring of 1915. It is thus seen that by spring, 1915, Great Britain will have seven additional modern battleships, besides a great number of old type warships which she has again placed in commission. Consequently, while from the beginning of the war up to December, the British lost no less than seventeen ships, representing a total weight of 129,220 tons, yet their fleet is even stronger than at the outbreak of hostilities. The losses inflicted on the other allied powers are insignificant when compared with those of Great Britain, being only twelve ships and representing a displacement of 23,340 tons.

The foregoing changes are arranged in a very convenient form, there being stated the number of ships available at the beginning of August, those which have since been lost, and those gained by commission and capture. And in addition there is, in the first supplement, an instructive presentation of the use Great Britain has made of her commercial ships. During the period considered she utilized no less than ninety-seven large commercial ships, representing some 300,000 tons, as auxiliary cruisers for the protection of commerce or for the transportation of troops; and employed thirty-six other ships for military purposes, thirteen for hospital uses, and 550 smaller craft for naval purposes.

The second supplement contains naval statistics of Austria and Germany, as obtained from official data at the outbreak of the war, which had been excluded from the war issue of August, 1914. The data appear in the form of tables, plans, sketches, silhouettes, etc., customary in the regular issues of the Handbook. In condensed form, it is seen that Germany had at the beginning of August, 1914, the following warships: 37 battleships, ranging from 11,000 to 25,000 tons; 16 armored cruisers, 11,000 to 26,000 tons (including her battle-cruisers); 36 small protected cruisers, 2600 to 4900 tons; 13 small unprotected cruisers, 220 to 1600 tons; and 8 coast cruisers of 4150 tons. Austria had 16 battleships, ranging from 5600 to 21,370 tons; 2 armored cruisers, 6000 to 7400 tons; 6 protected cruisers, 2300 to 4800 tons; and 6 river gunboats, 300 to 500 tons. It is thus seen that Austria and Germany had 140 warships in addition to about 250 torpedoboats and between 30 and 40 submarines.

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*An Introduction to the Study of Government.* By Lucius Hudson Holt, Ph. D., Lt. Col., U. S. Army, Professor of English and History, U. S. Military Academy. New York: The Macmillan Co., 66 Fifth Ave. 5½"x8". 388 pp. Cloth. 1915. Price, $2.00.

In twelve chapters and an appendix the student is given an instructive survey of the fundamental principles of government and the many theories as to their application. A feature of the book is the insertion, after each of the chapters but one, of what the author has designated "Statistics and Illustrative Citations." These contain many interesting facts and references.

Government; sovereignty and the constitution; the organization of government; the legislative; the executive; the judiciary; the electorate; political parties; local government; government of dependencies; the functions of government; and unnecessary or optional functions of government, are the subjects of the twelve chapters. In the appendix are given the constitutional laws of France, the constitution of the German empire, and the constitution of the United States.

In the classification of governments, the author makes no attempt to present a single set of categories, but very helpfully presents a classification by means of a combination of the members of three sets: (1) (a) autocratic, (b) aristocratic, (c) democratic; (2) (a) hereditary, (b) elective; and (3) (a) unitary, (b) federal. The classification is illustrated diagrammatically.

In discussing the seat of sovereignty, the author calls attention to the fact that, in the United States, it is not, as popularly supposed, in the hands of the people, but is to be found in a combination of two-thirds of both houses of Congress and the legislatures of three-fourths of the commonwealths. And further, in discussing the electorate, he cites the fact that even such functions as are exercised by the electorate in states where suffrage is most widely extended are restricted to about one-fifth of the population.

On the subject of sex restriction of suffrage, the author very successfully holds a mid-course: for the suffragists he admits, "The reasons for this restriction are historical and traditional;" and for the anti-suffragists he states, "The advantage to the state * * * is dubious"; while he concludes, "All that can be said at present is that the cause seems to be gaining steadily in democratic states throughout the world."

In his preface the author states that the cause of his writing was that no book of the precise character he had in mind was in print. That fact, together with the success with which he has accomplished his task, makes the work a useful addition to the family of books.

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*Notes on Field Artillery for Officers of All Arms.* By Captain O. L. Spaulding, Jr., U. S. F. A. U. S. Cavalry Association, Fort Leavenworth, Kansas. 6¼ "x 9". 207 pp. 15 il. 2 maps. Cloth. 1914. Price, $1.25.

In the second edition, the author has brought out a work which, as compared with the first edition, is much enlarged and of correspondingly greater value to the general military student.

The conception of the present work is well expressed in the preface to the present edition in which Captain Spaulding says: "While the original idea was to provide only an elementary book, introducing the subject of field artillery to officers of other arms, conditions in our service have now changed and it seems that the time for so narrow a conception has passed."

The present war in Europe is illustrating daily the value and dependence placed upon artillery of all classes The meager reports of the operations which are received through the medium of the daily press emphasize the important rôle which artillery is playing in the present war.

In war, that commander is most successful who employs for the work in hand the most suitable tool; and, by assigning to each element of his command the task to the accomplishment of which it is best suited, ensures a coordinate and economical employment of his whole force, both offensive and defensive. One of his most important elements is the artillery. It is not necessary for him to be a master of all artillery technique, but he should know its capacity and its limitations, to the end that he may not assign to the artillery tasks beyond its powers, nor hedge it about with unnecessary restrictions. By having a clear idea of what he reasonably may expect from each arm, he can better regulate the action of the whole to secure co-operation and the maximum results. As concerns the artillery, *Notes on Field Artillery* aids in bringing about this essential knowledge. It is one of few books in our military literature which puts before the general reader the essential information of modern field artillery.

In the chapter on "Matériel," Captain Spaulding, in this edition, describes fully the 3-inch field gun. Using this gun as a standard, he then gives the principal points of difference of the other field artillery weapons, the mountain gun, the howitzers, the heavy field gun, and the principal types of foreign guns.

An excellent feature of the book is the chapter on ammunition supply.

Taken as a whole, the book is well written and is a valuable addition to the military library, not alone of the field artilleryman, but of the general military student as well.

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*Germany and Europe.* By J. W. Allen, Barclay Lecturer in Modern History at Bedford College, University of London. London: G. Bell and Sons, Ltd.; New York: The Macmillan Company. 5" x 7½". 133 pp. Cloth. 1914. Price, $1.00.

Recognizing that "a right statement of the adversary's case is the beginning of understanding," the author, in his foreword, informs the reader that "an honest attempt has been made to state a case for Germany"; and so earnest has been the attempt that the statement of the case for Germany is probably the most interesting section of the book, as well as sufficiently strong to make it necessary that one, in reading it, shall be constantly on guard to avoid yielding to the mesmeric influence of "the will to power." Indeed, on page 18, the author himself confesses that "there are elements in this 'German' way of seeing things with which the present writer is in strong sympathy." He quotes from Nietzsche, "Man does not really pursue happiness: only an Englishman does that," and himself asserts, "The most perverted idealism is better than the animal instinct for comfort."

The high plane on which is pitched the moral philosophy of the lectures, for the book first materialized "in the form of public lectures given at Bedford College, last October," cannot be too strongly commended.

In addition to "The Theory of International Militarism" and "Germany," the volume contains a third and a fourth section entitled, respectively, "The Coming of the War" and "England."

In the section on England, the author, defending the alliance of England with Russia, regrets that he has not space in which to write at length on Russia, and tells us: "If by 'democracy' we mean merely a form of government, it is quite ludicrous to denounce Russia because our particular arrangements do not or may not suit her. If, on the other hand, democracy means something vastly deeper and more important than forms of government, if it means a spirit, a point of view, and a quality informing the life and thought of a people, then I can say that while I see a great deal of democracy in Russia, I do not see much of it in England. One might, indeed, go much further, and say that while, in that sense, England is the least democratic of all European countries, and the most completely under the dominion of the superstitions of 'class' and 'rank,' Russia is probably the most democratic of all."

The book is, on the whole, one of the strongest and most interesting that have appeared on the subject of the issues involved in the European conflict.

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*An Englishman's Call to Arms.* Reprinted from *The Daily Mail.* 4 pp. Price, one penny.

*England, Germany and Europe.* By James Wycliffe Headlam, M. A. Reprinted by permission from the *Church Quarterly Review.* 24 pp. Price, twopence.

*Britain and Turkey. The Causes of the Rupture.* Set out, in brief form, from the diplomatic correspondence, by Sir Edward Cook. 31 pp. Price, twopence.

*The Economic Strength of Great Britain.* By Harold Cox. 8 pp. Price, one penny.

All from the Macmillan Company, St. Martin's Street, London, England. 5½" x 8½". Paper. 1914.

From the Macmillan Company have been received four pamphlets treating of certain phases of the war, or wars, in which Great Britain is now engaged.

*An Englishman's Call to Arms* is a reprint from *The Daily Mail* (London) of an eloquent patriotic appeal to his countrymen from an unnamed Englishman, who has taken as his text certain words attributed to an English officer, Captain Norman Leslie, who has given his life in consonance therewith:

"But count the loss naught. It is better far to go out with honour than survive with shame."

*England, Germany and Europe* is a reprint from the *Church Quarterly Review*, for October, 1914, of an article by James Wycliffe Headlam, M. A., in which is presented a brief survey of German policy of recent years, as now beheld by an Englishman in the light of the present war; and an exposition of "the balnace of power" that is unusually intelligible to one who is not an European.

*Britain and Turkey* is a résumé by Sir Edward Cook of the British "White Paper" of "Correspondence respecting events leading to the rupture of relations with Turkey." It presents the salient facts of the "White Paper" briefly and interestingly, and incidentally acquaints one with amusing happenings of the great war as it is carried on in the East: "Moslems in Aleppo district are reported to have been so inveigled * * * that masses seem to believe German Emperor has embraced Islamic faith."

*The Economic Strength of Great Britain* is a short pamphlet by Harold Cox, setting forth the freedom of England from serious economic disturbance on account of the war. According to the author, there is no distress from poverty, the unemployment in November, 1914, being practically the same as that in November, 1913, and practically the only industry in which there is great depression being the cotton trade.

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*Course of Instruction Prescribed for Student Officers in the Ordnance School of Application (Sandy Hook Proving Ground) in Chemistry of Explosives, Oils, and Coal.* By Captain B. W. Dunn, Ord. Dept., U. S. Army. Ordnance Department Publication. 8" x 10½". 33 pp. 1914.

This pamphlet contains a series of 54 exercises and 10 problems, covering the chemistry of explosives, oils, and coal, with special references to service material, and is divided into three parts. The course was originally prepared by Captain (now Col.) B. W. Dunn, Ordnance Department, and has been revised from time to time to bring the subject matter up to date.

Part I consists of 45 exercises, of which the first nine are quantitive analytical experiments designed to illustrate the principles of stochiometry. Most of the next thirty exercises are devoted to the testing of service explosives; e.g., tests for moisture, ash, and volatiles; use of the nitrometer; stability tests; determination of percentage of nitrogen; and use of the impact machine in testing for sensitiveness. The last six exercises in Part I take up the preparation of service explosives, and the methods in vogue for determining the force or power of each.

In Part II an introductory statement of the classification and uses of oils is followed by exercises dealing with the usual chemical and physical tests of lubricating oils; viz., tests for acidity and for saponifiable matter; determination of specific gravity; cold test; and tests for adhesion and viscosity. The last three exercises give the common methods for determining ash, sulphur, and B.T.'s. in coal.

The problems which constitute Part III are of two classes: first, those having to do with the different forms of powder grains, and the effect of varying the dimensions of each; and, second, those involving the chemistry of explosives, such as calculation of temperature of explosion, volume of gas evolved, and pressure developed.

The foregoing synopsis of the pamphlet indicates at once its interest for the Coast Artillery officer.

While most of the exercises require for their accomplishment laboratory facilities and apparatus quite out of reach of the average officer, yet a careful perusal of the pamphlet will yield much valuable information relative to the characteristics and uses of our service explosives and oils.

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*Pages d'Histoire.* Paris: Librairie Militaire Berger-Levrault, 5-7 Rue des Beaux-Arts. 4½" x 6½". 64-166 pp. Paper. 1915. Price, 60 centimes a number.

In our number for January-February, 1915, mention was made of the series, *Pages d'Histoire*, being issued by the Librairie Militaire Berger-Levrault.

According to the general plan, the series is composed of nine divisions: (1) *L'explosion, etc.;* (2) *Les pourparlers diplomatiques;* (3) *Les Communiqués officiels;* (4) *Atlas-Index de tous les théatres de la guerre;* (5) *Les mises a l'ordre du jour;* (6) *Pangermanisme.* (7) *Au tribunal de l'histoire;* (8) *La guerre et la presse mondiale;* and (9) *Les opérations militaires.*

Of the first division, five numbers have appeared, the first five numbers of the general series. Their subjects were given in our January-February number.

Of the second division, three numbers have appeared, *Le livre bleu anglais, Le livre gris belge,* and *Le livre orange russe.*

Of the third, five numbers have appeared, bringing the record to November 30th.

Of the fifth division, six numbers have appeared, bringing the orders to November 10th.

Of the eighth division, two numbers have appeared, leading articles from the papers of Paris and Bordeaux.

Of the fourth, sixth, seventh, and ninth divisions of the series, no numbers have appeared.

The series present an interesting view of the war from the French side.

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*Military Field Note Book.* By Lieuts. G. R. Guild and R. C. Cotton. Menasha, Wisconsin: George Banta Publishing Company. 4" x 6". 76 p. 1 il. 1914. Cloth. Price, $0.75.

This Note Book comprises seventy-six pages that may be styled fixed, in that they are bound in the covers, and a detachable pad, or "filler," of one hundred message blanks and sixteen field diary pages.

The seventy-six fixed pages are made up as follows: One page for personal data, such as Nos. of field glasses and pistol, length of pace, distances traveled by horse at the different gaits in ten minutes, who is to be notified in case of casualty, etc.; one page for important addresses; one for important telephone Nos.; one for important general orders concerning field service; six for detached service and company duty record; six for notes of permanent record. Then begin printed pages, of which the contents are: addresses of military dealers; lists of baggage and equipment; information concerning transportation; tentage table; information concerning supplies, field engineering, and topography; signal codes; useful numbers and data, information concerning field orders, battles orders, etc.; road spaces and camp dimensions; and information concerning marches, security and information, combat, target practice, and first aid.

If correctly used and kept up to-date, a copy of the Note Book would be of inestimable value to every officer.

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*A Working Knowledge of Spanish.* By Lieutenant C. I. Crockett, 2nd U. S. Infantry. Menasha, Wisconsin: George Banta Publishing Com pany. 5" x 7½". 100 pp. Cloth. 1915. Price, $0.75.

The contents of this book are: three pages concerning the alphabet, accentuation, and punctuation; twelve graded lessons comprising, each, elementary grammar, a partial vocabulary, and a reading lesson for translation from Spanish to English and *vice versa;* and thirty-four pages of a general vocabulary.

In his preface, the author states that the work is intended for the use of noncommissioned officers, and he claims for it nothing beyond enabling the student to converse intelligently with Spanish speaking persons.

While the book is not designed for use as a conversation manual, or guide, yet it is unfortunate that it has not been made of a size suitable for carrying in the pocket, in order that it might have lent itself to study out of one's room.

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*Trois Mois de Guerre* (August-October, 1914). By S. R., membre de Plusieurs Sociétés Savantes. Paris: Librairie Militaire Berger-Levrault, 5 Rue des Beaux-Arts. 4½" x 7". 31 pp. Paper. Price, 25 centimes.

From the Librairie Militaire Berger-Levrault has been received, in addition to the numbers of *Pages d'Histoire,* eslewhere noticed, a similar pamphlet, *Trois Mois de Guerre* (*August-October, 1914*), by "S. R., membre de plusieurs sociétés savantes."

The little pamphlet contains five chapters, of which the subjects are: the origin of the war; the operations during August; the retreat of the Allies and the battle of the Marne; the battle of the Aisne; and the battle of Flanders.

The title page displays an interesting mingling of the names Joffre and French, with "*Fata viam inveniunt*" underneath, indicative of the harmony and cooperation the Allies see in their commanders in the western theater of operations.

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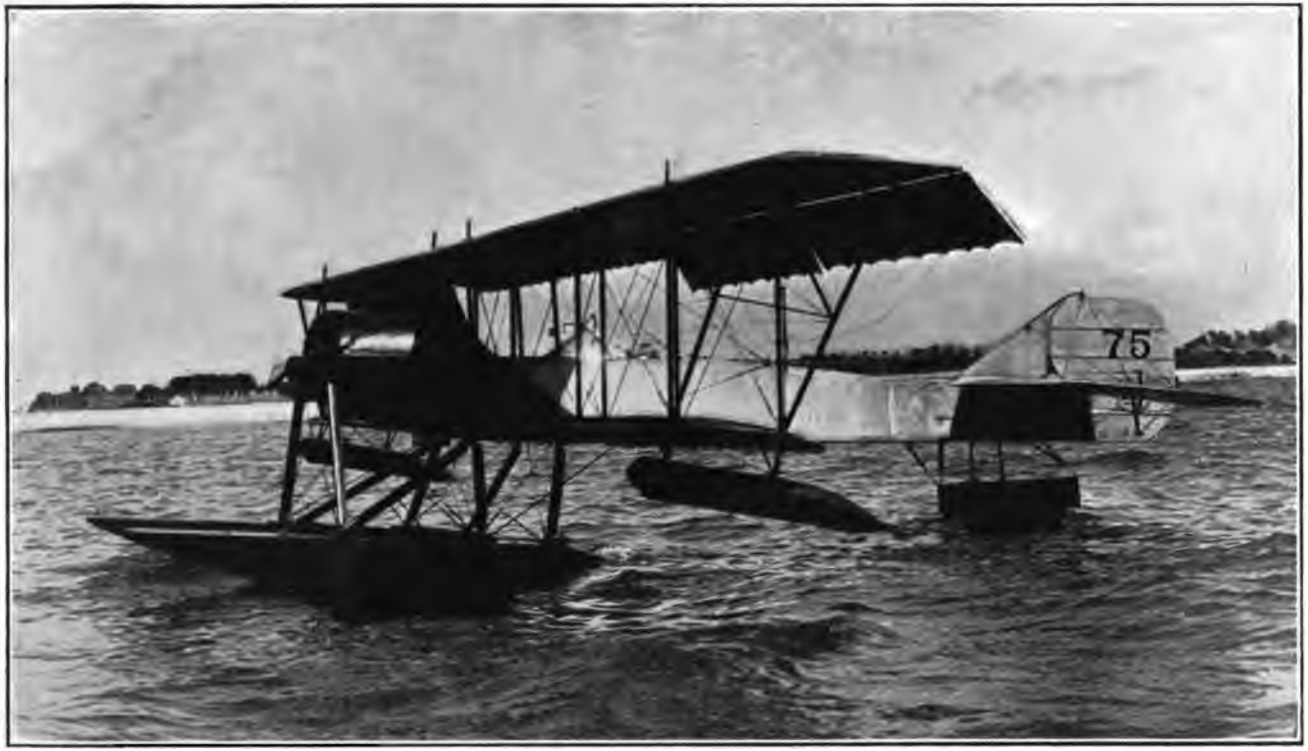
*Field Sanitation. A Manual for Non-Commissioned Officers.* By Major J. S. Wilson, M. C., U. S. Army. Menasha, Wisconsin: George Banta Publishing Company. 4" x 5½". 125 pp. 21 il. 1914. Cloth. Price, $1.00.

This little volume, which is designated a manual for noncommissioned officers, will be of use to commissioned company officers as well. Its size adapts it for carrying in the pocket, and it contains the facts and figures which one would probably not remember from a study of the prescribed texts on military hygiene.

Its contents are: camp diseases; personal hygiene and clothing; water and its purification; subsistence; wastes and their disposal; first aid; and sanitary service in campaign.

*Frontispiece.*



*Photograph by Stephen Cribb, Southsea.*

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# THE TACTICS OF HARBOR DEFENSE, INCLUDING A DISCUSSION OF PLANS FOR DEFENSE AGAINST NAVAL ATTACK AND ORDERS FOR CARRYING THEM INTO EFFECT

BY 2ND LIEUTENANT REUBEN N. PERLEY, COAST ARTILLERY CORPS

In a dissertation such as this, in order that we may prescribe limits for our thoughts, it is perhaps well that we define our subject. According to Webster, we are considering "the science and art of disposing military and naval forces for battle, and the performance of military and naval evolutions"; and, in such consideration, we are concerned with an application to harbor defense. In brief, our subject includes: (1) the tactical disposition of (a) matériel, and (b) personnel; and (2) the evolutions (as indicated by commands) necessary for adequate harbor defense. Subdivisions (1) (a) and (b) are so distinctly pre-war tactics, that they might possibly be regarded as "military policy," yet they so closely concern the subject matter of subdivision (2), that a thorough discussion of them will render subdivision (2) their natural conclusion.

## 1. DISPOSITIONS

### a. MATERIEL

In obedience to logic, we must reach a decision as to the possible methods of attack by a naval foe, and, eventually, as to the methods which are most probable. In this, I know of nothing more helpful to us than a close study of the "Coast Artillery War Game," as perfected by Major William Chamberlaine, Coast Artillery Corps.

Modern navies are composed of warships which may be conveniently classified as follows: (a) heavy ships, *i.e.*, superdreadnoughts, dreadnoughts, battle-cruisers, battleships, and armored cruisers; (b) medium draft ships, *i.e.*, protected cruisers, scout cruisers, gunboats, and monitors; and (c) light ships, *i.e.*, torpedoboat destroyers (including torpedoboats) and submarines. In addition to warships, modern navies make use of (d) auxiliaries, *i.e.*, aeroplanes and landing parties. This grouping is general and considers relative draft, caliber of gun, cost, and use. The characteristics of the groups may, and do, overlap, but this fact will be fully considered as we proceed.

(a) *Heavy ships.*—These are built, not for harbor attack, but to "seek out and destroy the enemy fleet" or parts thereof. Their field of action is the high seas. Naval authorities do not give weight to the possibility of harbor attack in determining the specifications of these huge fighting machines. This is evidenced by their thin protected decks, seldom over three inches thick, which are no protection whatever against mortar fire, as well as by their draft, which does not permit of maneuvering in shallow and confined harbor and river waters. We must not infer, however, that these ships will not take part in harbor attacks. On the contrary, they may play a rôle which, though supplementary, would have great importance, even to the point of becoming the deciding factor, in such an evolution, and they *can* and *will* play this rôle if the defending troops are deficient in tactics or marksmanship.

Most harbors are approached by one or more definite channels; but to think that any navy would cause one or more of its heavy ships to attempt to run by the forts into the inner harbor, except in rare cases (at least before the major caliber batteries were destroyed), would be an error, such form of attack, in the normal case, not calling for serious attention. For the benefit of the skeptical in this matter, however, let us list the following reasons against a run-by: the great cost a single ship, sometimes ten millions of dollars; the con-erable time required for the construction of one, never less n one year; and the important armament of a single ship.

Those three material risks (of cost, time, and gun power), in view of the almost certain destruction of one ship by mine fields, by torpedoes fired from submarines or other defense ships, or by fire from major caliber or smaller shore batteries at the short ranges which obtain in nearly every harbor, where the channels pass under the very noses of some guns; in view of the probability of a ship's running aground at one of numerous turns in channels; in view of the fact that crippling of the leading ship would cause those astern to "pile up" or run aground, due to the restricted maneuvering space; and in view of the fact that, after arriving within the harbor, the ships would often be subject to mortar and gun fire, or at least would be marooned and to be again useful would have once more to run the gauntlet of the batteries—those risks are sufficient, it is maintained, to rule a run-by out of consideration in the normal case.

The real danger from these sea monsters, then, lies in the power and range of their primary armament. The modern super-dreadnought is fitted out with ten or a dozen 14-inch long caliber guns; while, omitting a few marked exceptions, our harbors are defended by 12-inch (or even smaller) short caliber guns with an effective range considerably inferior to the naval 14-inch gun. Consider, for a moment, a clear day, a division of four of these super-dreadnoughts coming to anchor just beyond the effective range of the defending 12-inch guns: by means of charts and bearings, the individual ships can determine their positions precisely, and, incidentally, the ranges to all shore batteries (British admirality charts are so accurate in detail, that the United States Navy still uses them for areas not yet charted by the United States Government; and foreign intelligence offices are thoroughly familiar with the location of our batteries); after one or more ranging shots, this division is prepared to fire with impunity and deadly accuracy (the Japanese navy owed its accuracy of fire at Port Arthur to predetermined ranges to shore batteries from points in the outer harbor; Japanese agents, in the capacity of servants to the Russian officers, had learned the bearings of range points before the outbreak of war); we are, then, obliged to consider the effect of a salvo of from forty to forty-eight 14-inch projectiles exploding in the immediate vicinity of one of our 12-inch batteries, and close view of a turret full of 14-inch guns and their projectiles is an impressive aid in making deductions.

The question of the caliber and location of our major caliber defense batteries is our most serious problem in harbor defense, and is one which should be faced squarely and settled promptly.

With none of the displacement difficulties that confront naval constructors and ordnance officers, it would seem that we could equip all of our harbors on the system of "all big guns" of range equal to, or greater than, the most powerful guns afloat. Of what use are our 8-inch, our 10-inch, or even our 12-inch guns, if we cannot reach the enemy, who is firing effectively upon us?

The necessity of a superiority of range is more obvious because of the small number of defense guns that can return the fire of a clever enemy. How many of our harbors can boast of forty-eight major caliber guns? How many have not areas which are covered by only one battery? The accuracy of the enemy's fire decreases proportionally as his fear of being hit.

Our mortar friends maintain that our big guns should be of the indirect-fire type, and they advance as reasons that the hidden pits offer no aiming point to the enemy; that their fire is not masked by islands or headlands; that their accuracy of fire, so long as the pit salvo system is in vogue, will remain high; and that hits by mortars are far more effective than hits by direct-fire guns, for the thinness of the deck armor practically guarantees that each hit shall result in a projectile's bursting within the armor of the ship, with consequent damage to the ship's vitals.

Major caliber batteries must be located on sites which offer the largest fields of fire, and which provide for the maximum number of guns concentrating on the main channels of approach and on deep water areas. The very fact that powerful, efficiently manned guns are located at favorable points covering channels, is in itself the guarantee that heavy ships will not attempt a run-by. Islands and headlands in advanced positions are most objectionable in ruining otherwise favorable sites, as they invite raids on searchlights, observing stations, and separate batteries, because of the partial shelter they afford.

Our pre-war tactics, then, for defense against the heavy ships of group (a), are the dispositions above stated, and are based on the conclusion that attacks by those ships will be at long range. We might expect: (1) a reconnaissance in force to determine the location of shore batteries, stations, and searchlights; (2) a direct attack at long range upon individual batteries; (3) a secondary attack with heavy guns to cover the operations of torpedo craft and landing parties.

(b) *Medium draft ships.*—The ships of this class play a secondary and unimportant part. Their speed and armament render them useful for raids on outlying searchlights and stations; but their action will be limited to comparatively safe areas.

The study of pre-war tactics in connection with this class, calls for the abandonment or protection of all searchlights and observing stations now located within easy range of possible positions of ships which themselves would be free from the return fire of shore batteries. In some cases these accessories could be transferred to more protected positions, perhaps on islands near the center of the harbor entrance. Changing their location would be more desirable than the addition of batteries, for, obviously, the concentration of defensive power in few units, would result in simplicity in its manipulation.

The writer has steamed into several Atlantic coast ports aboard one or another of our own ships of war; and, next to the aids to navigation, he has found the most prominent objects on the landscape to be numerous observing stations and batteries, which were distinguishable by their hard and straight lines. Much has been done to form natural skylines, that these straight edges may be made less visible, but more remains to be done. It is possible that the use of periscopic sights with azimuth instruments will make bomb-proof base-end stations a possibility; or such stations might be installed as supplementary stations.

(c) *Light ships.*—Destroyers and submarines are the most likely to penetrate harbor defenses. A flotilla of destroyers, with their oil burners, may, if aided by a friendly sea breeze, very quickly cover a harbor with a dense smoke screen. The effect of this ruse is well known to navy men, for its employment is a regular occurrence in operations between the torpedo flotilla and the main fleet. Sometimes nature provides its own screen in the shape of mist or fog or rain.

Submarines may remain submerged for hours at a time; or, by moving very slowly and poking their periscopes above the surface at long intervals, and then just long enough to get bearings, they may remain effectively hidden, particularly in a light haze. Those who have searched for submarines know that, when they are steaming at some speed with periscopes above the surface, a white wave or wake trailing toward the rear is a tell-tale in smooth water; but that, when the water is covered by white caps, or the submarine is stationary during the period the periscope is above the surface, the presence of the underwater fighter often remains a profound secret.

Torpedo craft then, because of difficulty in picking them up, are dangerous to mine fields, to shipping within the harbor, and possibly to dry docks. Destroyers will undoubtably be used in raiding searchlights and observing stations. Before the outbreak of hostilities, we should be sure that all mine fields are intact, are covered by light batteries, and that all anchorages are covered by artillery. Mine fields should cover all channels. Submarines and torpedoboat destroyers should be assigned to harbors, both because of their patrolling value and because of their usefulness in counter-attacks. Possibly torpedoes could be fired to advantage from certain points on the shore line.

(d) *Auxiliaries.*—The European war exemplifies the use of aircraft both for attack and defense. We may expect reconnaissance by aeroplanes from the fleet, and must not be taken by surprise, if, in the course of their evolutions, they drop an occasional bomb into a mortar pit, or upon an observing station. This again suggests bomb-proof observing stations, using inconspicuous periscopic sights. Each fort would find some protection in a late type gun designed to fire at airships. Like submarines and destroyers, aeroplanes are valuable as defensive weapons. Their use consists for the most part in attacking hostile air-ships, and in reconnaissance.

Fog, and other weather cloaks which offer shelter for expeditions raiding mine fields and the inner harbor, are equally friendly to landing parties. Outlying stations, and even batteries, must not only be provided with defense against direct fire from ships in favorable locations, but also from attacks by improvised infantry and field artillery. Here, then, is the occasion for mobile supports in the neighborhood of harbor fortifications. These troops, be it said, should be under the direct tactical command of the coast defense commander, as we shall see later; and they should be equipped in part with field pieces.

Our discussion has brought up possible methods of attack, and we have reached conclusions as to which are the most probable. Furthermore, we have considered the disposition of the primary elements best suited for defense against those attacks. We shall now look into the matter of the disposition of auxiliary elements for control of all defense elements.

The battle station of the coast defense commander should be centrally located, not far in rear of the major caliber defense batteries, and it should have a comprehensive outlook. This may be effected naturally by the contour of the ground, or artificially, by a structure, such as a tower, skeleton mast, or high building. The equipment of the station might well include: direct telephone, wireless, and visual signaling connection with all fort command stations, with local headquarters of all mobile supports, and with the commanding officer of the naval elements; observing instruments; miniature "Coast Artillery War Game" board with ample land areas, the constant operation of which, in time of action, will keep the coast defense commander constantly informed regarding batteries in action, searchlights in action, troops in action, ammunition expenditure, casualties, and the position, strength, and intentions of the attacking forces; and all records which the coast defense commander may desire near at hand. This central station, with its permanently installed communication facilities, makes the coast defense commander the direct tactical commander of the situation, and insures coordination of the many elements.

The advantage the enemy has, due to the fact that he is the attacking party and his intentions cannot be known, is greatly increased in night operations. Hence, efficient employment of searchlights is essential. As to their location, there may be stated: (1) that proposed sites should not be unduly exposed to direct fire of ships at short range, or to landing parties; (2) that lights should be so located that rays of light reflected from the targets shall reach the batteries which the lights are to serve; (3) that one light can serve two or more batteries, only when there is little liklehood that those batteries will be used simultaneously; and (4) that in selecting sites it must be remembered that light beams should never be crossed.

### b. PERSONNEL

As the tactical disposition of the matériel has been discussed as pre-war tactics, so also should the tactical disposition of the personnel, in so far as it may.

The coast defense commander, whatever may be his rank in time of peace, should be so brevetted, at the outbreak of hostilities, as to guarantee that he shall be senior to all other officers (militia, reserve, support, and naval) taking part in the defense of the harbor. This infers, and assumes, that the coast defense commander shall command bodies of mobile troops detailed to support the harbor batteries against landing parties. This tactical command can be readily exercised, as suggested above, through the aid of permanently installed telephone and signal stations on the mainland. Branch field telephone sets could connect local commanders with the signal stations in question.

Many valuable men are included in the personnel of coast artillery troops of the militia, and these will be ordered to the forts in war time. A judicious measure, therefore, would place efficiency records of all militia officers and organizations in the offices of the proper coast defense commanders. These commanders will then be in a position to assign the militia officers and units, at the outset, intelligently. Perhaps it would be well to pair off each militia field officer with the regular officer of corresponding rank, and provide that they act as reliefs for one another. Similarly, the organizations could be paired off, as for example, a regular and a militia company could be assigned to the same mortar battery, one company to a pit. This arrangement would probably give confidence to the militia organization. This eventuality could be borne in mind in the regular assignment of companies to batteries in time of peace.

As assistants, the coast defense commander can designate members of his staff as Intelligence Officer and Signal Officer, with general duties outlined as follows:

*Intelligence Officer.*—Keeps war diary, and supervises the operation of the "War Game" board (mentioned above), which is in the coast defense commander's station and which is the graphic record of the military condition of all elements of the command.

*Signal Officer (or Communication Officer).*—Assigns, under the direction of the coast defense commander, the searchlights to the several forts, supervises the sending of all messages, which are invariably sent by wireless, by telephone, and by one form of visual signaling. Each fort and signal station should be equipped with the necessary apparatus, including ardois night signal set. The coast defense commander's station is, in this sense, a signal station.

Fort commanders, local support commanders, and naval commanders, are executive officers, so far as their tactical functions are concerned. They carry out the details of the general instructions received from the coast defense commander. Orders to them are brief and follow the plan of field orders for mobile troops, though far more brief. They will contain such information of the enemy as is known; the plan of action; and then instructions of a general character, such as the amount of ammunition to be reserved. The method in which the fort (or other) commander fights his batteries or units, is the prerogative of that officer himself, and is one concerning which he has studied at length during time of peace. He knows what projectiles will penetrate at the angle of presentation at hand, and he should not be hampered by detailed instructions during action. The time of the coast defense commander will be fully taken up with matters of far greater import.

Since the introduction of fort commands, battle commands should exist only on large posts, where the batteries and fields of fire are spread over too great an area for efficient control by one officer. The term fire command might well become obsolete, as being an unnecessary link between the fort commander and the battery commanders. The term mine command is useful, but it should be equivalent to battery, as it contains about the same complement as a mortar battery. In this arrangement, the mine command would comprise the mine field, its accessories, and the batteries covering the mine field, together with the personnel assigned.

Submarines, destroyers, and aeroplanes, with their complements, should be assigned fo rduty under the coast defense commander. Their actions should be controlled direct from the central station.

### 2. EVOLUTIONS, AS INDICATED BY COMMANDS

The phraseology of commands and, as far as practicable, of all messages should be that advocated by Major Chamberlaine in his book on the "Coast Artillery War Game"; for example, 1. ANDERSON——, TARGET——; 2. BUCKROE——; 3. ARMORED CRUISER DIVISION, LINE AHEAD——, SHIP NO. 1 ——; 4. FIRE WHEN IN RANGE, is a type command given to a battery commander by a superior commander; and 1. TARGET———; 2. BUCKROE———; 3. ARMORED CRUISER DIVISION, LINE AHEAD———, SHIP NO. 1———; 4. TRACK, is a type command given by a battery commander to the elements of his command.

The coast defense commander is normally in touch with the Navy Deparment and obtains from it all possible information of the enemy's naval strength in our waters. He concludes that certain classes of the hostile ships are likely to appear off the harbor. This information is supplemented by reconnaissance by the aeroplanes assigned to the harbor. The value of this patrolling is considerable in good weather, and somewhat less at other times. Fast destroyers can operate at some distance from the entrance of the harbor and should bring back early information of the approach of a hostile fleet.

When close to the harbor, the operation of the "War Game" board is begun. All persons report result of observations to superior commanders. Trial shots are fired, if possible, before the fleet is sufficiently close to learn the location of the batteries firing. The coast defense commander notes the direction of approach of the fleet and considers the angle of presentation and the range; and accordingly sends messages to the appropriate fort commands, designating their targets, if any, with such restrictions on the fire as may be deemed advisable or necessary. Targets are not assigned to fort commands until the coast defense commander is ready for the junior officer to begin active fighting at discretion. When assigned a target, a fort commander proceeds to destroy that target in as short a time as possible with due regard to the ammunition supply. The coast defense commander should be kept informed of any batteries that are put in action. Batteries, or larger commands, may be assigned to areas for purposes of observation only. They report all unusual occurences on their own initiative.

The coast defense commander changes assignments, or makes new assignments at his discretion. All casualties are reported.

# THE AEROPLANE IN COAST DEFENSE*

By 1st Lieutenant SAMUEL H. McLEARY, Coast Artillery Corps

## Naval Attack on Fortifications

In order that we may understand the utility and probable employment of aeroplanes in connection with seacoast protection, we should first consider the usual forms of naval attack and the ordinary methods of meeting such operations.

Naval attacks on a coast line will depend upon the object to be attained, and, as the multitudinous phases of politics, national policies, etc., cannot be foreseen with any great accuracy, we can hope to provide for only several probable objectives of the enemy. Accordingly, we may assume that the enemy's plans will be based upon one of the following considerations:

1. To seize points of strategic value.
2. To destroy shipyards, naval stations, etc.
3. To destroy shipping or commerce.
4. To disembark an army for land operations to the interior.

In so far as coast fortifications are concerned, we may disregard item 4, since those fortifications have been constructed to prevent the enemy from successfully carrying out only the first three of the above mentioned missions. To do this they must withstand naval attacks of several forms, such as:

*a.* Bombardment at long range.
*b.* Direct frontal attack.
*c.* Raids on mine fields.
*d.* Run-bys.
*e.* Blocking.

Such forms of attack may be made singly or in combinations.

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* Solution of a special problem assigned in the Department of Artillery and Land Defense, Coast Artillery School.

Heretofore it has been more or less of a general plan to conduct an assault on a fortification in several stages, the formation, time, and duration of attack, etc., depending upon the particular object in view. Raids on mine fields would usually be made at night, after the searchlights had been located and disabled; bombardments would be conducted by capital ships, after a reconnaissance had disclosed the position of batteries, ranges, and areas of fire of guns; run-bys would be undertaken only with the mine fields cleared or materially reduced. In whatever form the attack is made, it must be *after* the approximate location and strength of the various elements of the defense have been determined. This information is derived from general data obtained in time of peace, supplemented by reconnaissance. Reconnaissance, therefore, is seen to be of prime importance; and, in the past, notwithstanding that such operations have been conducted at considerable expenditure of time and energy, they have frequently produced results of no great value. Now, however, we find these operations greatly modified by the advent of the aeroplane. The attacking fleet no longer operates on guess work, to the former extent, but proceeds with full understanding of the situation. Let us see how the aeroplane has appealed to the Navy as an instrument of warfare.

## THE AEROPLANE IN NAVAL ATTACK

The annual report for 1912 of the Chief of the Bureau of Navigation, U.S.N., summarizes the matter as follows:

### COMTEMPLATED USES OF AEROPLANES IN NAVAL WARFARE

A. They can be carried, stowed, and used by all large ships—

(1) To reconnoitre an enemy's port or to search out his advanced bases and to assist in the operations of a blockaded or a blockading force.

(2) To locate and destroy submarine mines, submarines and dirigibles, and to assist in the operations of submarines and torpedoboats.

(3) To damage an enemy's docks, magazines, ships in repair or under construction, dirigible sheds and other resources.

(4) To provide means of rapid confidential communication between a fleet commander and the commanding officer of a cooperating force on shore, or the commander of another fleet or division.

B. They can be carried by all scouts and large cruisers to extend the "eyes of the fleet" in naval scouting.

C. They can be carried with ample supplies and camp outfit, on board any naval supply auxiliary for scouting at advanced bases and for extensive use with expeditionary forces.

The results for the fleet would be: the possibility of using fewer vessels for a designated object; decrease in fatigue; improved spotting; and better service of reconnaissance and observation, in the possibility of observing greater areas with greater accuracy, which comes from the substitution of the aeroplane for the ship in such work.

### *Reconnaissance*

It is evident that the service of reconnaissance is the most valuable duty to which the aeroplane is to be assigned. While the fleet remains far from the fortification, its aeroplanes can fly over the works, locating the positions of batteries and determining the number of guns. Observers in aeroplanes can clearly note the nature of the channels, since these are easily distinguished by experienced observers. The number of auxiliaries, naval vessels, etc., can be ascertained, and the presence of submarines noted, for submarines are easily seen, even when entirely submerged. Thus the aeroplane will disclose the strength and location of the principal defensive elements of the fort, and will leave the enemy in the dark as to the strength of the fleet, or as to its location.

In naval tactics the aeroplane would precede the destroyers, locating the enemy's submarines and acting as an advance aerial patrol. If a reconnaissance is to be made, the aerial observers and pilots will be assembled, and each pair given a portion of the area as its particular section to be explored. Usually, two separate machines will cover each section, as a safety precaution. Thus all the area will be completely covered.

### *Offensive*

As for the destructive power of the aeroplane, little is positively known. It is true that bomb dropping has been practised considerably; but, so far, the results have not been conclusive. The effect of a bomb dropped from an aeroplane is purely local, and the inaccuracy of the aiming has been very great. The present war in Europe has* given us one successful attack on a dirigible shed, by a bomb dropped from an aeroplane, and numerous failures. Accordingly, while we may expect a moderate local success (if accuracy of aim can be attained), yet no great destruction can be anticipated from an aerial bombardment. (See Appendix "A.")

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* November, 1914.

### *Spotting*

Another and important use of aircraft will be for spotting. It is apparent that it is difficult for vessels to observe the deviation of their shots from the targets, especially at extreme ranges, and when the target is a shore battery. In the latter case, no "splashes" can be observed, and the terrain will not be the level, smooth surface that the sea affords. But with an aircraft to cruise at a considerable altitude, the fall of shots can be closely located; and by using the information thus obtained, the fire can quickly be concentrated on the target. Thus long range bombardments become a danger of much more menacing character than heretofore. That such use of modern aircraft is not visionary, is evidenced by the field artillery operations of the present war. It was first practised by the French, who provided machines for the artillery commander's use for exclusively artillery purposes in control of the fire of the batteries of his command. In this connection, it is interesting to note that the employment of old style aircraft for artillery fire control was first successfully employed in this country in the Civil war, when an observer in a balloon directed artillery fire at "Island No. 10."*

## DEFENSE AGAINST THE AEROPLANE

With all the foregoing advantages claimed for the aeroplane, it is evident that we cannot expect future fleets to be unsupplied with this new auxiliary craft, and it becomes imperative for us to consider means of meeting this element of offense to which we shall be subjected.

The forms of defense that immediately occur to the thought are:

(1) Concealment.
(2) Anti-aircraft guns.
(3) Combat aeroplanes.

### CONCEALMENT

In this connection must be considered the visibility of objects from a high altitude. At a reasonably safe height, large objects such as seacoast batteries can be seen quite well, and especially would this be the case with our usual type of construction. But if the emplacement is colored so as to blend with the terrain, or screened by large spreading trees and vines, the difficulty of observing it will be considerably increased. Still, it appears to be an exceedingly difficult task to completely protect a large battery from detection by aerial observers, and concealment is not be relied upon.

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* There also occurred in 1862, the first real aerial reconnaissance of a position in which the observer started for a certain point, reconnoitered, and returned to that point. This was a military balloon reconnaissance, at the of Yorktown. The balloon was at an altitude of 1000 feet, when the or rope parted and the balloon drifted over Yorktown, then back again current of air of opposite direction in a lower stratum. Notes of the y's position were made during the flight.

In order that we may have some idea as to visibility of terrestial objects seen from above, we may glance at the following remarks of a military observer:

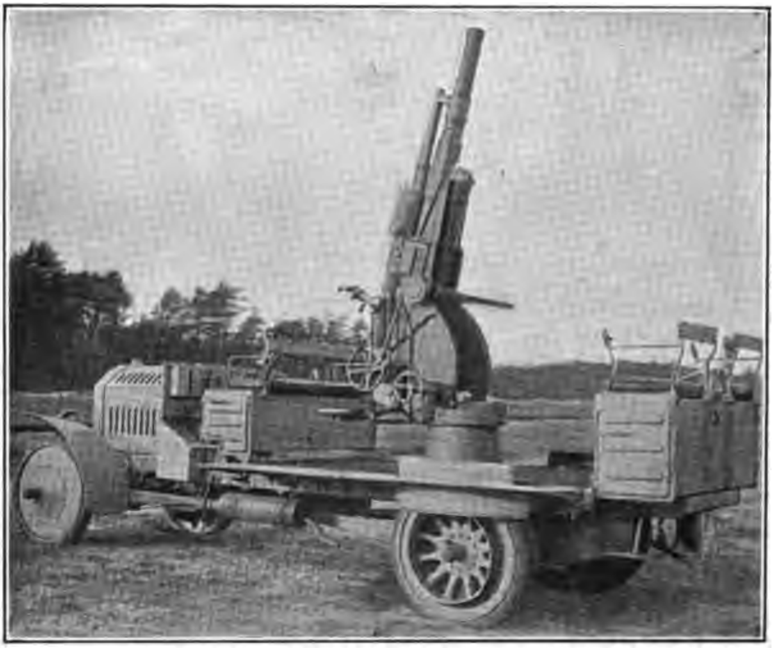
> On a clear day it is quite easy to carry out observations at a height of 3000 to 4000 feet. In misty weather, however, or when clouds are low, we should have to come down and take our chance of being hit by fire from the ground.
>
> At 3000 feet on a clear day, individual carts can be seen, and horse vehicles distinguished from motors. Individual squadrons and companies marching along a wide road can be seen two or three miles off, but troops on narrow roads with high hedges may escape observation.

The aeroplane to be fairly safe from fire directed from the the ground, must be at an altitude of over 4000 feet. But I have been able to observe coast fortifications to some extent, and it has been my experience that major caliber emplacements can be detected without difficulty at over 4000 feet, and that, though R.F. (3-inch) batteries are not so easily seen unless very prominently located and isolated on favorable terrain, still they can be identified at considerable heights. Of course, the clearness of the atmosphere and the inclination of the sun's rays (casting shadows) play a very important part; and although we cannot expect to be constantly under the condition most favorable for aerial observation, still we should consider such possibilities. The desirability of concealment of batteries, therefore, is more for protection from observation and aerial reconnaissance than from aerial bombardment, at least in the present stage of efficiency of aerial bombardment.

But though I believe we need have little fear of such an attack on emplacements in the immediate future, yet development along these lines is so rapid that it would be foolish to conclude that protection from aerial bombardment will never be required for emplacements; and when we consider magazines and storehouses, we find that the aerial bombardment is capable of more serious results even now, provided the bombs are of sufficient size and explosive effect. These targets are likely to be larger, and normally insufficiently protected from overhead attack, and in case they are struck the results are more serious. Accordingly, such structures should be not only well concealed but also specially protected against attack from above.

### ANTI-AIRCRAFT GUNS

Another possible use of aeroplanes is in the destruction of shipyards, etc., for the protection of which a fortification may have been established; and a successful employment of an aerial fleet in such an enterprise would cause the fortification to fail in its mission. And although such a raid seems improbable at present, on account of the crudity of aerial fire control apparatus and the small size of aerial projectiles, yet this condition of affairs will not continue, improvements being sure to appear in this, as they have appeared in other methods of warfare. But our fortifications could not deal with such an attack, with their present equipment.



*Photograph by Boston Photo News Co.*

KRUPP 7.5-CM. (2.95-IN.) ANTI-AIRCRAFT GUN 1632

This gun can be trained through an angle of 75 degrees and is pivotally mounted on a specially constructed motor car.

The evident present lack of our fortifications in methods of defense against this new weapon, aircraft, might lead us to consider an increased armament as a probable solution of the problem; but a mere *increase of number* of guns of the types already emplaced, would not serve the purpose, for they are admittedly inappropriate. As a consequence, we must look to a *new type* of high-angle-fire weapon, such, for instance, as the Krupp anti-aircraft gun, or an improved form. (Though the present war has shown the anti-aircraft gun to be only moderately successful at observing altitudes, yet it must not be regarded as a failure.) It will be evident that a gun such as the circumstances demand must have a mounting that will give high angles of elevation, quick traversing, wide arcs of fire, a rapid rate of fire, a small recoil, and a high muzzle velocity. These conditions have been met in the Krupp gun described below.

The Krupp firm has brought out three types of anti-aircraft guns:

(1) *The more simple type, with field mounting.*—Maximum elevation, 70°; traverse, 360°; caliber, 2.6 inches; projectile, 9 lbs.; muzzle velocity, 2050 f.s.; weight, 1925 lbs.; hydraulic recoil brake; maximum range, 28,550 ft. (9516 yds.); maximum altitude, 18,800 ft.

(2) *For use on motor car.*—Maximum elevation, 75°; traverse, 360°; center pintle; caliber, 3 inches; projectile, 12 lbs.; muzzle velocity, 2060 f.s.; weight, 2540 lbs.; hydraulic recoil brake; maximum range, 30,000 ft. (10,000 yds.); maximum altitude, 20,000 ft.

(3) *For shipboard and coast defense.*—Maximum elevation, 75°; center pintle; caliber, 4.2 inches; projectile, 40 lbs.; muzzle velocity, 2300 f.s.; weight, 6600 lbs.; range 44,500 ft. (14,833 yds.); altitude, 37,620 ft.; can be used as ordinary cannon if necessary.

In all these cases, a rapid rate of firing is given by an automatic opening and closing of the breech. Sighting is carried out most effectively by the use of an appropriate form of sighting telescope, in combination with a general finder which covers a wider field. There is also a range-finder by which the distance is *first* obtained, the indications being afterwards directly given in such a way as to make it possible to point the gun for different heights of an air-ship without loss of time, the use of firing tables being dispensed with.

### *The Projectile*

The question of the kind of projectile which is best adapted for firing upon balloons or air-ships is of great importance. It is recognized that shrapnel will penetrate the balloon envelope, but without doing much damage—at least of an immediate nature, since the holes are closed again for the most part by the internal pressure of the gas, and the loss of gas, in consequence, is not rapid. It is thought by some that the most effective form of projectile is a special kind of grenade, designed to explode on the interior of the balloon and to bring about ignition of the gas. The new projectile designed by the Krupp firm is intended to accomplish this. It is also furnished with day and night tracer. The grenade is detonated by a sensitive non-delay fuse. Tests were made against captive balloons.

Experimental firings on kites by infantry and machine guns were conducted at several places during the year 1911. It was shown in these firings that effectiveness is not at all certain, even at less than 3000 ft. altitude. The trials were conducted at Chalons.

The choice of projectiles for balloon gun firing is a matter on which diverse opinions have been given. The *shrapnel* has the advantage of great searching effect, aid in ranging by time bursts, and probable large number of perforations of the balloon envelope. On the other hand, bullet or fragment perforations are but slight injuries; the fuse-setting could seldom if ever be the same for two consecutive shots; and, because of the larger caliber, slower rate of fire, and less flatness of trajectory than the small shell firer, the advantage of greater searching effect would be much decreased.

Various means of destruction of balloons have been devised, some based upon the inflammability of the confined gas, such as an explosive substance of high calorific power, and shrapnel which on bursting release flaming darts; other means being projectiles filled with explosives that form gas to neutralize the gas in the balloon, shrapnel bullets joined by chain, and projectiles with metal wings.

In late wars it has been estimated that 1000 to 3400 cartridges and 80 to 100 shrapnel shells have been expended for every man put out of action. The aerial attacker justifies still greater expenditure, it being admitted that 8000 cartridges are justified for an aeroplane with one observer.

High explosive shells, exploding in the locality of an aeroplane, will have a very marked effect, the concussive effect of the shells being very great in the air. It has been reported that an aviator, flying at 800 ft. over a field battery, was fired at by blank cartridges and almost upset by the concussion.*

The concussive effect of exploding shell would more seriously affect the personnel than the matériel. There has been one instance of this nature reported in the present war, an aeroplane being brought to the ground because the bursting of a high explosive shell in proximity to the machine benumbed the pilots, who lost control of their machine as a consequence.

An interesting discussion of firings upon dirigibles has been contributed to the public by a European authority, and in view of the great future hoped for for the new anti-aircraft gun, it has been inserted below at length:

### FIRING AT DIRIGIBLES†

Rigid aircraft (dirigible balloons of the so-called rigid systems) are less sensitive to gas losses, because they have many small supporting balloons that are enclosed by a stiffened envelope.

Projectiles of small arms and machine guns are able to penetrate this envelope, if the striking velocity is still about 50 m.-sec. So, shrapnel balls of exploding shrapnels receiving from the bursting charges an acceleration of 50 or more meters, their penetrative power at appropriate distances of burst for all range possibilities of the projectiles is beyond question.

Projectiles of small arms and machine guns, as also shrapnel balls, produce perforations in the envelope, which, on account of the elasticity of the enveloping material and displacement of the fibres of the texture, are smaller than the caliber. A square hit by an artillery projectile rends a hole as large as the caliber, but the remaining shreds hang loosely during the escape of the gas and so the outlet is reduced in this case also.

In case the inflating gas is nearly in equilibrium with the pressure of the surrounding air, as is possible with the rigid types, only a very slow outflow of gas takes place through the holes; while in the case of the excess of pressure in the semi-rigid types, the velocity of the escaping gas is dependent upon that excess. For this reason, rigid types of air-ships, even after many hits of the envelope, can sometimes maintain themselves in the air long enough to withdraw from the firing range of the enemy. Semi-rigid types are sensitive to hits in the envelope. It will thus depend upon the reserve buoyancy still to be relied upon, whether a balloon that is hit can land within the sphere of its own troops or will be caused to fall rapidly.

All motor balloons are subject to the danger of combustion. To set them on fire, artillery shells are used from which an inflammable composition issues; or shrapnels are filled with a composition, in place of shrapnel balls, which, taking fire after the burst of the shell, scatters many fiery elements. Upon the impact of the fire ball or dart with the balloon, the envelope is set afire, and the escaping hydrogen gas then burns in the oxygen of the air in a constantly increasing flame, until the balloon is entirely consumed, which requires but a few minutes.

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* The following words of Mr. Witner, a Curtiss demonstrator in Russia, are of interest in this connection:

"Flying at an altitude of about 1500 feet, we flew directly between the ships and the targets. There were five ships at practice and four of them fired when we were about a mile away; but the fifth fired when we were directly over it. We could see the fire and smoke as the broadside of 10-inch guns was fired, and I then expected to feel something unusual, but to my surprise we flew on without the slightest trouble. On the return trip we flew on the opposite side of the ships, but this time only about fifty feet high; and at this altitude we were roughly shaken."

† Translation obtained from the General Staff.

### THE TRAJECTORY

a. Every firearm has a certain line of departure by which the greatest horizontal range can be reached. Included between this line of departure and the horizontal through the muzzle is the angle of greatest range, which is dependent upon the muzzle velocity, the velocity of rotation, and the form (including the distribution of mass) of the projectile, and is less than 45°.

The line of departure of the greatest horizontal range, is the dividing line between the so-called lower and upper angle groups: for every shorter horizontal range there is a corresponding line of departure in the lower and one in the upper angle group.

b. The travel diminishes in the ratio with which the line of departure approaches the vertical; *i.e.*, the projectiles do not rise as high when discharged in a vertical direction as is indicated by the greatest horizontal range.

c. The branches of the trajectory straighten out on the approach of the line of departure to the vertical, becoming straighter, while the highest portion of the trajectory is more curved.

d. When firing in a vertical direction, the trajectory is a straight line and the velocity of the projectile diminishes until reaching the highest point of flight, where the upward movement ceases and changes into a quick drop.

Even rifle ammunition discharged vertically drops with a final velocity of 60-70 m.-sec.

### RANGE

The reach of firearms, in the wider sense of the term, includes the horizontal or vertical distance which can be traveled by the projectile. The range of an arm, though a term which might be applied to the total reach, is, as a rule, applied to only a part of that total reach, being limited by the following conditions:

a. Small arm projectiles must still have enough force to penetrate an envelope or to wound a man, for which a velocity of more than 50 m.-sec. is required, and which is retained in vertical ascent, for the rifle up to 2300 m., for the carbine up to 2050 m., and for the pistol up to 1050 m.

Projectiles of pieces of artillery, on account of their bulk, have still the required force for the ranges and altitudes reached; and this also applies to the balls of shrapnels, when the distance of burst is not too great, for the reason that the balls, on the explosion of the projectile, as was stated before, are given an increase in their velocity.

b. The expected result of hits must be in reasonable proportion to the expenditure of ammunition.

c. Artillery ammunition with time fuse limits the range of shot.

d. While small arms can be aimed in every direction, the range of other rms is further limited by the structure of their parts.

e. The arrangements of sights in the case of small arms and machine guns do not permit the full use of the range against air-ships at inconsiderable heights.

The range of small arms and machine guns, on account of the penetrative power of the projectiles, was found to be 150 m. less than the full reach in vertical fire; while at elevations less than the vertical the range includes distances where the target can still be attained. A further reduction of the range with respect to the probability of hits was left out of consideration, except in the case of the revolver, since there are no experiments at hand, and since an endangerment of air-ships by volley fire can at least be expected.

Aeroplanes, on account of their small size, can first be discerned, as a rule, at a distance of about three kilometers, beyond the reach of field guns, for the greater part, as well as wholly beyond firing range of small arms. Aeroplanes flying over troops at an altitude of 1000 m. and even of 1500 m., remain for minutes at a time within the carrying distance of small arms of large caliber.

### AIMING WITH ALLOWANCE FOR TRAVEL OF TARGET

When an aerial craft is fired at with the elevation corresponding to its distance and height, the trajectory cuts the line of sight at that point where the portion of the air-ship aimed at was at the moment of the discharge of the shot.

In order to take the angular velocity into account, the arm must be aimed ahead such angular distance as will be covered by the balloon between the time of discharge and the time of arrival of the projectile at the balloon.

For the reason that the time of flight of the projectile must be taken into account for only an approximate distance, and owing to the velocity of aircraft being hard to estimate, the difficulties of firing increase in great measure; for it cannot be expected of the marksman or the director of the fire, surprised by the appearance of an air-ship, to enter into long-drawn-out considerations as to the exact aim, nor can it be expected of everyone to possess that sense peculiar to the huntsman of aiming ahead, without long practice.

Flying machines can, while moving laterally, change their position in elevation during the travel of the projectile as follows: at a distance of 500 paces, about 3 m.; at 1000 paces, 6 m.; and at 2000 paces, 12 m. Since the cone of fire for rifles in a vertical section of the trajectory in individual fire has, at 1000 paces, a diameter of 12 m., and at 2000 paces about 20 m., an aeroplane does not get beyond the effective zone of dispersion by a change of elevation during the time of flight of the projectile.

Air-ships traveling at considerable heights are to be fired at with small arms only when they have attained an angle of elevation of more than 45°, and then with a smaller adjustment of sight than is indicated by the direct distance.

### ESTIMATING DISTANCES

In order to keep the expenditure of ammunition within limits, it will be well to fall back upon some facts already at hand, for at least an approximate estimate of the distance.

The use of range-finders with two points of view is rendered very difficult by the movement of the air-ship.

In most cases, the method of automatically getting the range (Captain Aizier's method), can be employed with success. When two guns, separated as far as possible from each other, aim at one and the same point, the smoke produced by bursting shrapnels with like time fuses and fired at short intervals, one after the other, will appear with certain relative lateral position, making it possible to determine whether the point aimed at is nearer or farther than the regulated time-distances. (See Fig. 1.)

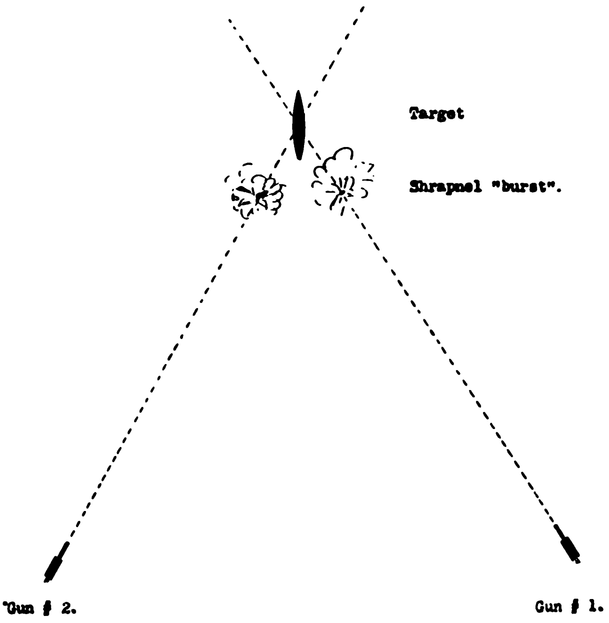


FIG. 1.

Range Finding Method of Captain Aizier

The guns are fired with fuses set for time of flight corresponding to an estimated range. Gun No. 1 is fired a brief interval (about two seconds) before Gun No. 2, thus causing its shrapnel to explode first. Accordingly, if the first "burst" is observed to the right of the second "burst," the range is under-estimated; if it appears to the left of the second burst, the range is over-estimated.

### SIGHT

It is to be remembered that, with an increase of the angle of elevation of the target, a smaller sight elevation is needed in order to reach one and the same direct distance; and that without consideration of the movement of the balloon and time of flight of the projectile, the following adjustments of sight are indicated:

| | |
|---|---|
| Angle of elevation of target below 30° | Sight elevation is that for the distance. |
| Angle of elevation at 70° .......... | Sight elevation is that for half the direct distance. |
| Near the zenith .................. | Sight is point blank. |

If a dirigible is approaching, a sight corresponding to a distance that is less than the time despite a possible error in estimating an additional few hundred paces (m.) is to be chosen; if it is departing, a sight corresponding to a distance that is larger than the time, despite an underestimate, is to be taken as the proper one.

Should the air-ship pass over the firing position, the normal sight is as a rule, to be used. Only when coming near at heights of over 1500 m. is the sight in the scale of paces equal to the height in meters.

*Repeating Revolver.*—Owing to the great dispersion at greater distances, air-ships are to be fired at only when they pass over the firing position at a height of 200 m. at the most. Aeroplanes in a flanking flight are likewise to be fired at only at 200 m.; an aim is to be taken ahead for only the single length of the craft.

Altogether, there can be firing only when there is no doubt that the air-ship is a hostile one. For this purpose, it will be necessary to distribute to the troops lists of air-ships similar to the lists of naval vessels, from which an outline of the front, side, and bottom of the aircraft, with principal dimensions and actual velocity, can be taken.

The difficulties of fire against aircraft are obvious, and it is little wonder that satisfactory results cannot be hoped for invariably. The present war in Europe has shown the anti-aircraft guns to be ineffective, unless the targets approach within short range and to low altitude; so, although improvements may be expected, and undoubtedly will come, still we cannot afford to depend exclusively upon such uncertain means for our protection.

## COMBAT AEROPLANES

After a careful consideration of all available means, we arrive at the conclusion that *the best defense against hostile aircraft, is aircraft of our own;* for, though such machines can not be depended upon to the exclusion of fortifications, as some zealous advocates of aeronautics seem to believe, it being out of the question to expect them to materially injure a battleship or even lighter vessels, yet their offensive operations would probably succeed against hostile *aircraft.* In the present war such offensive use is common. The following is taken from a report of Sir John French, commanding the British forces of the Allies:

> The tactics adopted for dealing with hostile aircraft, are to attack them instantly with one or more British machines. This has been so far successful that, in five cases, German pilots or observers have been shot while in the air, and their machines brought to ground.

The necessity for such aerial combat is real; for, while the overwhelming advantage in reconnaissance accruing to the force having an aerial fleet, over one not so equipped, is manifest, yet, in order that such a fleet may operate to the best advantage, when the enemy also has aircraft, it is necessary first to gain "control of the air." No force can be content with a mere interchange of information secured through aerial scouts—conflicts between such aerial forces is inevitable, it being indispensable, both in order to prevent the enemy from using his aircraft and in order to enable our own air forces to carry out their mission.

### KINDS OF AIRCRAFT

Before we can determine upon the types of machines that we shall employ, it is well to consider the aircraft that the enemy will utilize and the service we shall require of our own. There is no question that we shall find aeroplanes employed against us, and it is not out of reason to think that non-rigid dirigibles may also be encountered, for the latter could easily be transported to an advanced base, and there prepared for use; so we must be provided with machines suitable for combat with either form of aircraft.

As to the service to be required, the defense's machines will be sent to destroy the enemy's craft as soon as their presence becomes known; or they may be sent as a guard to protect scouts from molestation by the enemy. In either case, they must be strictly fighting machines, whose purpose is purely offensive. The particular characteristics of such machines, and present requirements, will be discussed later; it is sufficient for the moment to know that machines for the specific purpose of combat are required.

Then, with the "command of the air" assumed, the aircraft of the defense can proceed with their main purpose, reconnaissance; for just as their employment in reconnaissance constitutes the chief value of aircraft to the enemy, so it does to the defense. On the approach of hostilities, aircraft would constantly patrol the coast and vicinity of the fortifications; and with the great radius of action of modern machines, they could detect the approach of a hostile fleet a day's sail from the fortification. In this way, surprise would be eliminated; and with a knowledge of the number and character of the enemy's vessels, their direction of movement, etc., an efficient defensive plan could be arranged to meet the impending engagement. Such *strategic* reconnaissance would be effected by machines acting as a coast patrol, and not necessarily under the direct control of the fort commander. Their status would more nearly approach that of the coast guard troops.

*Tactical* reconnaissance, on the other hand, would probably be conducted by machines under the direct control of the fort commander. These machines would operate in the vicinity of the fortifications, observing the formations of the enemy, his landing parties and submarines. They would be able to identify types of vessels, and would give due warning of submarine raids on mine fields. No area in the vicinity would be available for the enemy in which to shelter his vessels from observation, and every move he made would be perfectly known to the defense.

Again, at night, it may be possible to employ aircraft as a supplement for searchlights. Searchlights are limited in range, and when in operation present a target to the enemy; so if a substitute could be found for use at the longer ranges, it would confer a great advantage upon the forts; and that, by means of the parachute lights and the buoy lights now being developed abroad, aircraft can afford such a substitute seems probable. Each machine, flying above the fleet, could drop brilliant lights designed to burn for several minutes duration and suspended from parachutes designed to fall slowly. With this illumination, the ships would offer good targets to the shore batteries, while the latter would not be betrayed. Moreover, the mine fields could be illuminated when raids were anticipated; and fleets would not attempt to close in at night, in face of efficient illumination of the above described character. Thus aircraft would render invaluable service at night, provided a suitably illuminated water area could be maintained for landing and starting; and that is easily arranged at all coast forts.

Not alone would the machines be serviceable against naval attack, but they would be of great assistance in repelling land attacks, observing formations of troops, number, movements, points of attack, etc., which emphasizes the importance of aircraft to a complete defense of a fortified point.

Now, with an understanding of the importance of aircraft to the defense, and having considered the types to be employed by the attack and the services to be required in defense, we may proceed to the selection of a type, or types, for the defense.

Aircraft may be classified under the following heads:

[illegible]

[illegible] discussed [illegible] the machines [illegible] government [illegible] been adopted [illegible] been installed in [illegible] the particular [illegible] we must consider that each type possesses advantages [illegible] in certain lines, and must weigh the two classes of [illegible] in order to decide [illegible] most appropriate for our purposes, resources, etc.

[illegible] proceeding to compare these machines it would be well to examine in detail the uses to which they would be put. Regardless of the type of craft, we should find it of the greatest advantage to employ them for the following purposes:

1. Strategic reconnaissance.
2. Tactical reconnaissance.
3. Spotting.
4. Combat.

*Strategic Reconnaissance.*—This consists in operations to cover a considerable territory in order to secure general information of the strength, location, and movements of the enemy. Flights of great length and duration are needed, as the enemy's operations may cover a wide field, and it is desirable to acquire information while the enemy is yet at a considerable distance. As the purpose of this class of reconnaissance is only to learn the general situation, and as considerable area may be traversed, it becomes necessary for the machine used to have high speed and a range of at least 250 miles.

Not only is it necessary for the aerial scout to secure information, but the celerity with which he delivers results of his reconnaissance to his commander, may be of vital importance. Therefore, the machine should be equipped with radio and probably other signaling devices.

It is interesting to note that it is this use of the aeroplane in the European War that has been most conspicuous. One military observer has even gone so far as to state that the aerial reconnaissance of both sides has been practically all of a strategic character.

*Tactical Reconnaissance.*—This implies the reconnoitering of the country in the immediate vicinity of the fortifications. It is clear, therefore, that the function of a scout in this case would differ materially from the function of a scout in strategic reconnaissance. It will not be the purpose to discover the larger dispositions of the enemy, but to place in the hands of the defender accurate information of the attacking forces, their strength and positions, movements, etc. With proper reconnaissance of this nature, *surprise* attacks would fail, and flank attacks could be thwarted. It thus becomes apparent that the aerial scout must observe in considerable detail, and be able to transmit information of the changing situations while it may still be of service, *i.e.*, with practically no delay.

In order to carry out his mission successfully, the tactical scout must fly with a sufficiently low speed to permit of careful observation: with high speed he would be carried from his area of reconnaissance, and would be compelled to leave many points unexamined. From this we see that a tactical scout should be equipped with a machine capable of slow speed. But in this case also, it must not be forgotten, prompt transmission of information is of the utmost importance; so high speed also should be available, and there should be provided suitable efficient signals and radio equipment. And, since it will be necessary to have the observer's attention entirely on his work of *observation*, a separate "pilot" is required.

*Spotting.*—The control of the fire of artillery, whether field guns or heavier ordnance, has always been a matter of the greatest importance; but with the universal employment of indirect fire, it has become an absolute necessity. So, in order to secure an elevation favorable for observing the fall of shots, European armies have had recourse to portable observing towers; but with the advent of aircraft, the artillerist, quickly realizing their possible application to his arm of the service, has given them an opportunity to prove their value as an adjunct of the artillery. As a means of fire control, aircraft have been used to a large extent in Europe, and France considers the service of sufficient value to assign aeroplanes for the exclusive use of the artillery commander.

Here also we find the element of detail required in the observation. The machine should remain in the vicinity of the field of fire; should be sufficiently slow to permit close observation; should be as invulnerable as possible; and should have adequate signal apparatus. Great range of action is not required; nor long duration of flights.

Since spotting is not difficult where isolated shots are under observation, even though it is doubtful if "splashes" from individual batteries could be differentiated in case several were firing on the same target, this latter fact should not be permitted to lead to an under-estimation of the great value of aerial spotting, especially at the beginning of an engagement.

*Combat.*—As stated before, the enemy may employ against us either aeroplanes or dirigibles, or both; so it will be necessary to be possessed of machines capable of meeting either class in successful combat.

In such an encounter, other things being equal, the machine that is the speediest, the quickest climber, and the most readily maneuvered, will have a tremendous advantage, being able to select the most favorable moment for engaging the enemy. From this we may state that a machine for combat should ve very swift, easily controlled, and a quick climber. Further, it should be armed, and its vitals should be protected from rifle fire. It should also be capable of considerable radius of action.

Having seen the variety of defensive uses, including combat, to which aircraft may and probably will be put, we should carefully consider the various types and models to meet the several conditions. It is evident that no single model can be expected to fulfill all the requirements for *all* the uses. Efficiency requires that we employ for each use a machine which shall be specially developed in the particular direction desired.

Let us compare, first, the two types, aeroplane and dirigible, as to qualities, considered in this connection, and we shall be able to decide upon the type best suited for our purposes.

| | Dirigible | Aeroplane |
|---|---|---|
| Speed.................... | 60 | 90+ |
| Radius of action.......... | 1800 (low speed) | 500+ |
| Duration of flight........ | 34 hrs. | Max. recorded, 24 hrs.+ |
| Carrying capacity (useful) | 16,000 lbs. | 500+ |
| Altitude attainable....... | 10,000+ft. | 20,000+ |
| Wireless range............ | 250+miles | 25+miles |
| Length.................... | 250–490 ft. | 30 ft. |
| Width..................... | ... | 40 ft. |
| Machine guns.............. | 2 | 1 |
| Cost...................... | $100,000+ | $6000–$7000 |
| Hangars................... | Elaborate structure | Tent or small shack |

*Strategic reconnaissance* demands high speed, an extensive radius of action (at least 250 miles), and means of quick communication. Hence it might appear at first glance that the dirigible were the best for the purpose, since its range of action is much greater than that of the aeroplane and its wireless range comparatively very great; it would be able to travel further and transmit its information from a greater distance—at least in good weather. Moreover, the dirigible possesses the advantage of more certain progress at night than the aeroplane; though, since observations are not extensive in the dark, this is not, except where very long distances are to be covered, such a great advantage as at first might appear.

On the other hand, the dirigible is less speedy than the aeroplane, is less weather-worthy in strong winds, and is under less certain control, especially in case of landings. And the duration of flight of an aeroplane has exceeded twenty-five hours and 1500 miles, though ordinarily a distance of 500 miles and five or six hours would be its practicable limit for scouting. But even this is seen to fulfill the requirements for strategic reconnoitering.

We therefore see that, for the purpose of strategic reconnaissance, either the dirigible or the aeroplane will serve, with, perhaps, an advantage on the side of the dirigible, because of its greater range of communication by radiotelegraphy.

There are, however, other points to be considered than the qualities of the machines themselves. The aeroplane requires only a tent, or small shelter, for its housing; while a dirigible hangar is a very expensive structure: fifteen aeroplanes can be purchased for the price of one dirigible and its hangar. So we must consider whether one dirigible is of more value to a seacoast fortification than fifteen aeroplanes; and in my opinion the answer would be in favor of the aeroplanes: the small space required for their storage; the simplicity of their preparation for expeditions; their high speed; their comparatively small vulnerability—all render them especially appropriate for use in a seacoast fortification. Furthermore, were we to employ dirigibles, we should be obliged to purchase them abroad; whereas, aeroplanes of the best quality are manufactured in our own country, and the advantage of using machines of domestic manufacture are numerous and obvious. Finally, Congress would never appropriate sufficient funds to equip the fortifications with dirigibles, even were they considered the most desirable aircraft; while practicable appropriations would permit the purchase of aeroplanes.

We decide, therefore, to adopt aeroplanes for this class of work.

*Tactical reconnaissance* requires a machine capable of operating at low speed over the neighborhood of the fortification, and possibly over the area of battle, on which account it must be as invulnerable as possible; for it cannot seek safety in great altitudes, since observation of details must be made. It is evident, then, that the dirigible is quite unsuited for such reconnaissance, as it offers a very large and vulnerable target. Its great range of action, large carrying capacity, etc., are of no especial advantage in this work.

Accordingly, we again favor the aeroplane and would decide upon the utilization of this class of aircraft for tactical reconnaissance.

*Spotting* being work that requires rather accurate observations; the observations must be made at moderate height and at low speed; and since they must be made in the general vicinity of the guns, the dirigible must be discarded from consideration in connection with this class of work, for the same reason it was rejected in tactical reconnaissance.

*Combat* demands offensive power and ease of maneuvering; and while the dirigible might carry more guns than the aeroplane, yet the aeroplane could easily out-maneuver it, securing all advantage of position and conducting the fight to its own advantage: the guns of the dirigible would avail it little, if they could not be brought to bear on the target. Accordingly, we should depend upon combat aeroplanes to conduct our offensive operations against hostile aircraft, and to gain "command of the air."

## MODELS OF AEROPLANES FOR DIFFERENT PURPOSES

Having now determined upon the aeroplane as our aircraft for all purposes connected with coast fortifications, it remains to be seen what particualr features should be embodied in the machine selected for the different purposes. That which is desired and that which is practicable, are not always identical; and, since we must depend upon actual accomplishment in aeroplane construction and equipment, we can consider only present practice.

### *Strategic Scout Machine*

Heretofore, it has been considered desirable to have a machine of this class very fast, single-seated, and preferably a monoplane, on account of the requirements of *speed* and *duration* of flights, such models being considered most suitable. But the development of aeroplanes has been rapid, and we now are possessed of machines capable of great speed and ability to carry considerable load, which enables us to furnish the strategic scout machine with an observer in addition to the pilot. This is a great advantage; for, though it is a fact that, where detailed observations are not necessary, a pilot who is also a skilled observer can render good service as a strategic scout when flying along *in good weather;* yet, when the meteorological conditions are unfavorable and require the pilot to devote his time to actual control of his machine, an independent observer is required. And since a scout should be available at all times, we cannot afford to depend for such service upon a machine that will fail as a scout under conditions that permit flight at all; so we should insist upon a two-seated machine of high speed, as the model for strategic scouts.

Whether we select a monoplane or a biplane is of little moment, provided each fulfils the requirements stated above; and the superiority of the monoplane in speed has been seriously challenged by the biplane of today. In fact, in this country there has geen no monoplane produced to equal our biplanes.

The necessity for the scout aeroplane to traverse hostile territory has caused many people to believe in armor for protection of the vitals from rifle fire, the belief being held abroad, as well as in our own country, and being extended to include even the strategic scout machine, despite the high altitude at which such a machine would ordinarily fly.

We may conclude, therefore, that for use as a strategic scout, we would select a machine of high speed, armored, and carrying an observer in addition to the pilot. Of such machines we have several makes in this country of speeds of 85 to 90 m. p. h. while carrying fuel sufficient for several hours and other necessary weight. Several are mentioned in Appendix "C."

### TACTICAL SCOUT AND SPOTTING MACHINE

Machines used for tactical scouting and spotting should have practically the same qualities. For both purposes, variable speed is most desirable, the high speed being used to cover distances and the low speed to make accurate observations. (Low speed is always desirable, on account of enabling safe landings to be effected.) Even a few months ago, very little range in speed was practicable; but progress has been so great lately, that we now find manufacturers willing and able to guarantee a speed variation from 40 m. p. h. to 85 or 90 m. p. h. So a valuable machine for tactical scouting and spotting is available.

Naturally, a machine that flies at comparatively low altitude and low speed, offers a good target for small arms and machine guns. Therefore we must protect our engine, personnel, and other vitals by armor sufficient to resist small-arm rifle bullets. This is in keeping with the general policy. Next, a two-seated machine is absolutely essential; for here, particularly, a trained observer must be able to devote his entire attention to his work, unimpeded by control of the craft. And rapid communication with headquarters being a requisite, a wireless equipment, or other efficient signal system, must be installed.

In addition to these features, it has been suggested that this class of craft should be equipped with a machine gun, to enable it to defend itself against hostile aircraft whose mission is to prevent the reconnaissance; but this suggestion does not appear to be the best solution of the problem; for, in order to employ a machine gun, another person must be added to the crew, or otherwise neither the pilot nor the observer could devote his attention to his proper duties. It would seem better to depend upon speed for evading the attack, or to be supported by combat machines.

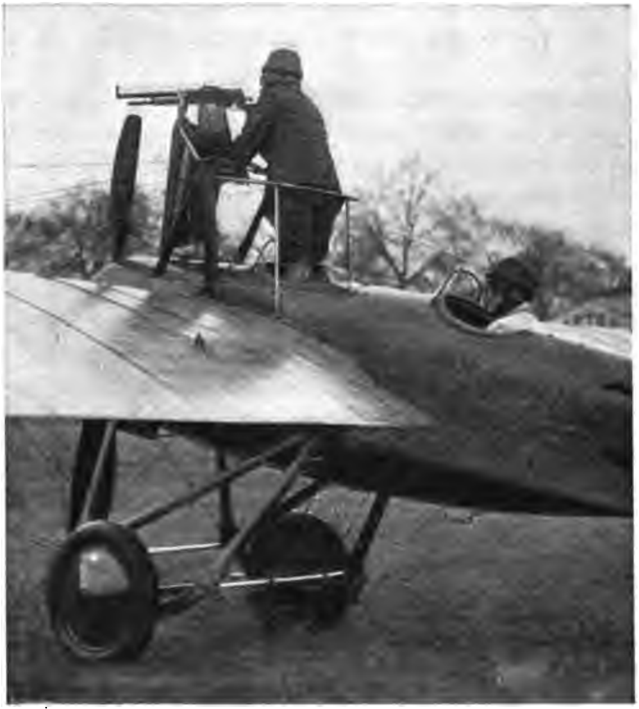
### *Combat Machines*

The combat aeroplane is a recent development; for, though the idea of using aeroplanes for offensive operations is not new, the most startling prophecies having come from the fertile imagination of journalists and others, since the very first successful flights; yet, until the outbreak of the present war in Europe, the employment of machines for combat was not very favorably considered. But the present hostilities have given us numerous examples of aerial encounters, and it appears that we may expect the future to show a marked development in that direction.

The offensive use of aeroplanes could take several forms, but the principal would be as follows:

Ramming.
Dropping bombs.
Using machine guns.

At the Vienna Aeronautical Meet, in 1914, a dirigible was accidentally rammed by an aeroplane. The result was tragic; the dirigible exploded, and both craft fell to the ground and were demolished. Thus was settled the important question of the feasibility of destroying a dirigible by means of an aeroplane But though such a procedure is an effective one, it is rather drastic; so means must be found for accomplishing the destruction of the enemy, while preserving the life of our own aviators.



*Flying.*

The Benet-Mercier aerial gun mounted on an armored Deperdussin monoplane

For this, numerous devices have been suggested, one of the chief of which is some form of bomb, the old idea of "dropping" bombs being here applied to a moving target. Inaccuracy of fire is to be expected; but in the case of an attack on a dirigible, this can largely be improved by approaching closely to the target from above. Incendiary bombs would probably be employed.

But while the large target offered by the dirigible renders it especially vulnerable to bomb-dropping, it is a different matter when one aeroplane attacks another. Here bomb-dropping would seem to be of very little value; and it is because other means seem impracticable that we find the custom growing of installing on aeroplanes small machine guns.

The fighting machines, therefore, must be equipped with light machine guns and must carry a gun-pointer in addition to the pilot. The vitals would necessarily be protected by armor. The speed should be high in order to permit of rapid maneuvering, and it is essential that the machine be able to climb rapidly. Thus we find our combat machine to be a high powered craft, capable of carrying considerable weight at high speed.

Methods of mounting the guns have been various. In the present practice, shown in the illustration, the gunner is posted behind his gun at the foremost part of the machine, thus obtaining unobstructed field of fire for his weapon. In the case of the "propeller driven" machines, the gunner is seated; but, where a "tractor" is employed, it becomes necessary to raise the gun mount sufficiently to permit of firing over the whirling blades, so the gunner assumes a standing position, and the training of the gun is so regulated by stops as to prevent accidental discharge into the "tractor."

There are three types of guns at present employed on aeroplanes.

Hotchkiss 37-cm. machine gun.
Benet-Mercier.
Lewis gun.

The first two are mounted on supports fastened to the machine, and as a consequence have little movement in elevation. The Lewis gun, being free, can be aimed in any direction. Whatever type of gun is used, its purpose is the same—to furnish a weapon capable of successful attack on the personnel and vitals of hostile craft.

### *Dispatch Machine*

There is one other use to which aeroplanes may be put to advantage, though the necessity for such employment will probably not be so frequent or imperative as for the other uses. I refer to a *dispatch* machine: one which shall convey messages or documents from one commander to another, or serve other duties requiring the prompt transmission of confidential instructions. Such a machine would preferably be a high speed, single-seated machine, capable of rapid climbing, and able to arise from or alight on rough ground. It would probably be made as light as possible, be without defensive means, and be able to fly at a great height, over long distances.

### NUMBER OF AEROPLANES REQUIRED

Having indicated the desirable models and their principal features, we should turn our attention to a decision as to the number and classes of machines to be assigned to a coast defense; and the question is not to be answered off-hand; for while, of course, all the above mentioned classes are desirable for their special purposes, we must face the fact that Congress would never appropriate sufficient funds to furnish a very numerous aeroplane equipment. With this as a basic condition, we are obliged, first, to select, from the various classes of machines, one model which best fulfils all the essential requirements specified.

In arriving at a decision on this point, we must bear in mind the various elements of the coast defense problem, not forgetting that the handling of the strategic situation is properly within the province of the commander of the mobile troops serving as coast guards; and that it is upon that body that the coast defense commander must depend for his information of movements not within the restricted neighborhood of the fortifications. That being the case, we may assume that proper strategic reconnaissance will be undertaken by those troops, and that their equipment of aircraft will be ample for the purpose. We may therefore eliminate the *strategic* scout from the aerial equipment of the forts. Similarly, we can dispense with dispatch machines. This at once narrows the types to the *tactical* scout, spotting, and combat machines. But the tactical scout and the "spotter," it will be recalled, embody the same characteristics, so may be considered as one type, which still further simplifies our selection. Now how does the combat machine differ from that type? Bearing in mind the requisites already specified, we find that the combat machine is merely a more powerful craft and armed, not demanding a wide speed variation but a high speed maximum. Aside from those features, there is little difference.

From the above remarks, we are led to the conclusion that we can find in the already developed tactical scout machine the best all-round aeroplane for the purposes of a coast defense command: by installing a powerful engine, insisting on a wide speed variation with high maximum, and providing a Lewis aeroplane machine gun, we should have in it a craft which would render valuable service, both tactically and for fire control, and be capable of becoming at a moment's notice a formidable antagonist for hostile aircraft.

Finally, the question of suitable landing fields being always an important one, and suitable fields not being always available in coast defense commands, our type machine should be some form of hydroaeroplane.

### ORGANIZATION

The question of the organization of the aviation service is one which has not yet been finally decided in the United States. Still, for a mobile division, we have a tentative organization suggested by the Signal Corps, which is as follows:

(a) Strategic reconnaissance,
  2 two-seated machines, 4 pilots and observers.
(b) Tactical reconnaissance,
  4 two-seated machines, 8 pilots and observers.
(c) Artillery fire-control,
  2 two-seated machines, 4 pilots and observers.
Total...8 machines, 16 pilots and observers.

| | | |
|---|---|---|
| In command of (a) | 1 officer. | |
| In command of (b) | 1 officer. | |
| In command of (c) | 1 officer. | |
| Supply officer | 1 officer. | |
| Pilots and observers, as above | 16 officers. | |
| Attendants | | 80 enlisted men. |
| | — | — |
| Total | 20 officers, | 80 enlisted men. |

Such would be the organization of the aviation service of the coast guards, for this body of troops being considered a mobile force is organized just as the regular mobile army.

It may be observed that the machines are really grouped in pairs. This is for the purpose of providing for possible accidents to a reconnoitering scout, experience having shown that a machine sent out for reconnaissance duty may fail to return; in which case, if operating alone, its information would be lost, but with two scouts operating together, one will probably return and the mission be accomplished.

Now, in a coast defense command, though the practice of operating scouts in "pairs" should be adhered to, the organization must be somewhat different. The organization for the mobile forces recognizes the predominant importance of the tactical scout, and indicates that at least four of the division's machines should be of the tactical scout model. Accordingly, since we have eliminated the strategic scout from the coast defense command and have adopted a modified tactical scout model for the several classes of work, including fire control, we may adopt four as an appropriate number of machines for each important coast defense, and two for each smaller. Though an enemy fleet would probably be equipped with six or eight aeroplanes, and though, for combat, we would naturally wish to oppose an equal number, yet, aeroplanes being very easily transported from fort to fort, a concentration could be made, when considered necessary, at the threatened point.

The organization for our four machines would be about as follows:

| | |
|---|---|
| 4 Aeroplanes..........<br>(with spare parts and<br>2 extra engines) | 1 officer in command.<br>8 officers (pilots and observers).<br>40 enlisted men. |

Such an organization, conforming to the mobile forces, would simply call for detachments from the regular Signal Corps aviation forces, the only requirement being that the observers should, as far as practicable, be acquainted with coast artillery affairs; and no difficulty should be encountered on that score, for the coast artillery seems to be more largely represented in the Army aviation work than does any other branch of the service. The detachments should be under the direct control of the coast defense commander, occupying in this respect, a position analogous to the coast artillery supports; and with uniformity of organization of the aviation services of the coast defense commands and of the coast guards connecting them, we could expect complete cooperation.

The cost of such a four-machine aerial equipment would not be excessive. In fact, the machines would cost no more than a concrete emplacement for a 3-gun R. F. battery, and would be of considerably more value.

### Importance of Aircraft

From the foregoing pages, we must arrive at the conclusion that aircraft are an important factor of war, and that we can hardly expect future hostilities between energetic belligerents to be conducted without assistance from aerial observers. In fact, that aircraft have arrived at a stage of development demanding the attention of all military nations is amply demonstrated by their wide use in the present European struggle.

In *Flying* of September, 1914, we find the following summary of aeronautic strength of the several warring nations, as taken from unpublished official sources:

> *France:* Aeroplanes, 1200 military, 500 added since by acquisition of private machines and output of factories. Dirigibles, 12 of close to 400 feet in length; 14 of less than 300 feet length; 5 privately owned, or 31 altogether.
>
> *Germany:* Aeroplanes, 600 military, 400 added since by acquisition and output of factories. Dirigibles, 12 Zeppelins of from 350 to 490 feet long; 23 dirigibles of other types, including those privately owned.
>
> *Russia:* Aeroplanes, 800 military, 150 added since. Dirigibles, 16 of different types, but mostly under 250 feet in length.
>
> *England:* 200 seaplanes; 300 army aeroplanes; 300 added since. Dirigibles, 15, mostly new, up-to-date machines acquired in the past twelve months.
>
> *Austria:* Aeroplanes, 350, of which all but 100 have been acquired since the beginning of hostilities. Dirigibles, 10, mostly under 300 feet in length.
>
> *Belgium:* Aeroplanes, 40, and 40 acquired since the beginning of hostilities Dirigibles, 2, one medium size, and one small.
>
> *Servia:* Aeroplanes, 40; dirigibles, none.

This is, indeed, a formidable number of machines, and indicates the great value ascribed to aircraft by the leading powers.

Now, we may inquire, what has been accomplished by these craft? It is difficult to answer this question: the movements of armies, the plans of action, the results of engagements, and other items of military interest are jealously guarded secrets, and little information of such character passes beyond the censors; we must await the return of peace before anything approaching complete information can be had.

However, notwithstanding the strict censorship, we do occasionally obtain items of apparent military value, and it is upon such information that the following record, taken from the *Washington Post* is based. The record is apparently as well authenticated as can be expected under the present condition of affairs; and, while not complete, is yet of sufficient length to serve as an indication of the valuable services possible from the new auxiliary arm.

*August 1.*—French aviator made an *unsuccessful attempt to drop bombs* on Nuremberg, Bavaria.

*August 4.*—German aviators dropped three bombs on the French fortified town of Lunéville. *Several houses were destroyed.*

*August 5.*—A German dirigible near Herve, Belgium, was fired on and brought down.

*August 6.*—Paris reported that five of the fifteen Zeppelins used in the siege at Liège were captured or destroyed.

*August 7.*—In a battle at Liège, between a Belgian in an aeroplane and a German Zeppelin, the former was killed and the Zeppelin was destroyed.

German aviators dropped manifestoes on the town of Vise, Belgium.

*August 8.*—The French aviator Perrin said he encountered a Zeppelin at Château Saline; fired twice and destroyed it.

*August 11.*—A small German airship was brought down at Czenstochowa, Poland, and four Germans killed. A German aeroplane was brought down at Namur; two officers, uninjured, were made prisoners.

*August 12.*—German aeroplanes were reported maneuvering along the Russian frontier.

*August 13.*—Three German aeroplanes at Dust were brought down by Belgian guns. Four German aviators were killed at Suwalki, Poland.

Two Germans came down from an aeroplane on the Dutch island of Schiermonik Oog and were arrested.

*August 14.*—A German aeroplane flying a French flag *dropped bombs* over Vessoul, France, *without damage.*

*August 15.*—Russian aeroplanes were seen over German territory.

*August 17.*—French troops brought down a German aeroplane near Dinant, Belgium, killing the pilot.

*August 18.*—Belgians brought down a German aeroplane at Geethetz. A German monoplane *dropped bombs* on the Lunéville public gardens.

*August 19.*—Austrian aviators *dropped bombs* in Montenegrin forts. The German aeroplane A-29 was forced to come down near Rotterdam, and a lieutenant was made prisoner. A German monoplane was brought down near Brussels; the pilot, with both legs broken, was captured.

*August 20.*—A German aeroplane soared over the trenches at Liège. A French dirigible *dropped bombs* on two German cavalry troops in Belgium *without damage.* The Dutch shot at several German aeroplanes scouting over Holland. Aviator Pegoud returned to Paris, telling of the wings of his machine being pierced by 97 bullets.

*August 23.*—Zeppelin No. 8 was destroyed by French shells near Cele, France.

*August 24.*—Bombs *dropped* in Antwerp by Germans *killed 10* and *injured 30.* One machine was reported brought down by Belgian guns.

*August 25.*—German aviators *attempted unsuccessfully to attack* Antwerp a second time.

*August 30.*—Pegoud sailed over Brussels, dropping pamphlets of encouragement for the Belgians to hold out. A German aviator *dropped five bombs* in Paris, *injuring two women.*

*August 31.*—A German aviator *dropped a bomb* in Paris which *failed to explode.*

*September 1.*—*Twelve persons were injured* in Antwerp by *bombs dropped* from a Zeppelin. *Two bombs* were dropped in Paris from a German monoplane.

*September 2.*—A fight took place in the air over Paris between two French aviators and three Germans; the latter disappeared when pursued.

*September 3.*—A patrol of Paris against further invasion by Zeppelins was begun.

*September 5.*—Russians captured a Zeppelin near Seida, taking 30 prisoners. German aviators dropped two bombs into Ghent. Two Japanese aeroplanes *dropped bombs* in Kiauchau, German territory.

*September 6.*—A German aviator was brought down near Svolen, Russia.

*September 7.*—Two were made prisoners when a German aeroplane was brought down near Lotteghem, Belgium.

*September 10.*—A French biplane, caught in an air pocket above the Bois de Vincennes, fell, killing two aviators and four persons in the street. Four others person were severly injured.

*September 15.*—Two Germans, forced by motor trouble to land in Belgium, stand off hostile peasants and carry away a magistrate in their aeroplane.

*September 18.*—Air duel between French and German aviators is reported. The German was wounded and his aeroplane turned over. He was picked up dead.

*London, Oct. 9.*—The admiralty announced to-night that naval airmen had made a successful attack on the German air-ship shed at Düsseldorf. A bomb, dropped through the roof of the shed, destroyed a Zeppelin. The flames that resulted were observed by the airmen rising to a height of 500 feet.

A simultaneous raid is believed to have been made on the Zeppelin base at Cologne, but of this no details have been given out. The feat would appear to have been in every respect remarkable, having regard to the distance of over 100 miles penetrated into country held by the enemy and to the fact that a previous attack had put the enemy on their guard and enabled them to mount anti-aircraft guns.

From these reports, we see that aircraft have been used for bomb-dropping and combat, though the former use has not met with unqualified success, usually producing but small local effects when sufficient luck has enabled the scouts to place their bombs near their targets. In combat, there has been an absence of ramming, the contest being decided by superior mobility and employment of firearms. Attacks from the ground by anti-aircraft guns have been moderately successful against dirigibles; and we must not overlook the fact that in most of these offensive operations, the machines have flown at low altitudes; in fact, no success at all has been obtained with bombs at more than 500 to 1000 feet.

These newspaper reports cannot be regarded as indicating the real purpose of the aircraft, for they have been used practically altogether for reconnaissance and spotting, the combats and bomb-dropping being secondary. In reconnoitering, they have proved themselves invaluable, while to their efficacy in fire control has been attributed the remarkable results achieved by the artillery.

What would have been the effect on our last war, had aeroplanes been available? At San Juan, the bombardment was probably solely for the purpose of driving the Spanish fleet from the harbor, under the assumption that it had taken refuge there; and, with a single aerial scout, the absence of the Spanish vessels would have been determined without the firing of a single shot, and much time and ammunition would have been saved. While at Santiago an aeroplane could have located the Spanish fleet and relieved the tension of uncertainty; could have determined accurately the fleet's strength and location and made possible a successful bombardment; and could have ascertained the weakness of the fortifications and facilitated cooperation by the Army.

Now that the effectiveness of the aeroplane has been demonstrated in Europe, we cannot afford to disregard the lesson: we are possessed of strategic points of great importance in the Panama Canal Zone and the Philippine Islands, and what would happen to those localities in case of an aggressive attack by an enemy supplied with aircraft? The opinion of Gen. Scriven, Chief Signal Officer, on this point, is interesting. He stated before the Military Committee of Congress as follows:

> If you look at conditions at the Panama Canal—I have happened to talk with Mr. Scott, well known throughout the world as having conducted some interesting experiments in bomb-dropping, who has informed me that he has dropped 100 pounds of nitrogelatin; and I believe the record shows that 400 pounds have been dropped from an aeroplane. Now, the question immediately comes up as to what would be the result of dropping 300 or 400 pounds of nitrogelatin on the lock or spillway. There is probably little difficulty in doing it, and should a foreign fleet be anchored beyond the range of the guns of our fortifications, some distance out—say, fifteen or twenty miles—aeroplanes may well be sent out and great damage to the Canal done.

While here again we have a form of bomb-dropping and all that it implies as to accuracy of aim, etc., yet, in addition there is the effect of the explosion in the canal, which, if the quantity of explosive dropped were sufficient, might occur as a land slide, or other damage of that character. If the locks, as they are said to be, are practically bombardment proof, requiring the actual placing of the explosive charge in the gates, they could withstand the aerial attack above mentioned; but whether or not they are as invulnerable as has been stated, remains to be demonstrated; and everyone will certainly agree that the risks of such a demonstration at the opening of hostilities are too momentous to be permitted.

And how is it with Manila? At Corregidor Island we have established extensive fortifications which will effectually prevent a successful naval attack on Manila Bay, or hostile occupation of the harbor; but are these fortifications invulnerable from the land side? That is a danger which becomes real and vital, once an emeny effects a landing and obtains control of the mainland; but, while without aerial machines we should be almost helpless, with a few aeroplanes, properly manned and equipped, we could hold our own: our mortars directed against the enemy's heavy ordnance, their fire, controlled by observers in aeroplanes, would prove too accurate and deadly for him to withstand.

The military aircraft has "arrived"; it is a grim reality; so we must prepare our fortifications to conform to the changed conditions. Assuming that our present armament and emplacements are to remain, we can improve their effectiveness by the following means:

1. All batteries and store-house magazines should be carefully screened by trees, shrubs, and creeping vines, and concealed from overhead observations by imitation of the surroundings. The placing of magazines underground would, perhaps, be a wise precaution.

2. Anti-aircraft guns should be installed; and it has been suggested that such guns be mounted on cars, capable of movement to any part of the fortifications, but that does not seem reasonable, for it would not be possible to cope with the great mobility of aircraft by such means. Rather should we mount such guns at the most vulnerable portions of the works, or on the flanks, connecting all by direct telephone communication. Special observers should be kept constantly on watch, and the control and command of the guns should be under one directing head. The anti-aircraft guns should constitute a Special Fire Command.

3. Anti-aircraft searchlights also should be available for preventing hostile operations at night. Such searchlights would be similar to our present ones in size and power, but

they should be arranged for more facile operation and training in all directions. In addition, we should need illuminating lights to enable our own machines to alight after a nocturnal flight. All these lights would naturally pertain to the Special Fire Command.

To the special anti-aircraft fire command should be entrusted the aerial protection of the fortification, the personnel being especially trained for their work. Identification of aircraft would be as essential as identification of warships, and much more difficult; for there seems no satisfactory way of distinguishing hostile from friendly aeroplanes. Colors, at over 2000 feet, are not clearly distinguishable. However, there seems to be a tendency for machines to develop along national lines; so it is possible that a trained observer might recognize the peculiarities of a craft and classify it by them. From this, it seems that observers must be trained for the work and should be selected men.

All these preparations and modifications have their value, and should certainly not be ignored; but, as has been pointed out already, it is to the aeroplane that we look at present for our most effective aerial defense. That fact is recognized abroad, where France, England, Italy, and Germany are establishing complete aerial patrols for their coasts. The effectiveness of such coast patrols has been demonstrated, and the insignificance of the cost of the service compared with a strictly naval patrol is obvious.

The coast defense aeroplane is, then, necessary; and while it is possible that some of our coast defense commands can manage without this aerial assistant, yet our important harbors, our points of strategic or great commercial value, cannot dispense with its services. The wonderful rapidity of the present development in aeronautics is but the result of a recognition of the tremendous advantage accruing to the forces best supplied with aerial scouts and spotters, and emphasizes the vital necessity for adequate aeronautical equipment: for the expenditure involved, there is no equipment that could be supplied a coast fortification which would render as extensive, as efficient, and as valuable service as aeroplanes. They have indubitably established themselves as indispensable auxiliaries of warfare, and each day but makes it more impossible for us to remain blind to this obtrusive fact. Let us hope that, in the near future, Congress may appreciate that the employment of aeroplanes in coast defense is not a visionary dream, but a real necessity—and supply them.

## APPENDIX "A"

### BOMB-DROPPING

This form of offensive action by aircraft has held the public attention more by its spectacular character than through any achievements of marked success. Terrible destruction to cities, armies, and fortifications has been freely and vividly predicted by the press, and even at the present time many residents of London seem to be panic-stricken through fear of bombardment by German aircraft. But, while the present war has given many examples of bomb-dropping, both from dirigibles and aeroplanes, the results have not been such as to cause dread among military commanders. Aside from a purely local disturbance, the aerial bombs have had little effect, and we have learned of only one attack which really amounted to anything. In that case, a bomb, dropped from an aeroplane at a height of only 500 feet, destroyed a dirigible in its hangar; but that was an exceptional case, the target being large, the altitude small, and the horitzontal speed of the aeroplane comparatively low. All other examples have demonstrated that chance plays the dominant part in such attacks; accuracy of aim has been exceedingly rare.

Undoubtedly the time will come when this primitive form of attack will be developed into a reliable and fairly accurate means of offense; but the time has not yet come. Still, even well-known writers are liable to permit their enthusiam to carry them away, as seen below:

> With an aeroplane, given the height by aneroid, speed by anemometer, and horizontal distance, accuracy of hits is but a simple matter of the parallelogram of forces, and a target can be quickly picked up by running fire from a bomb dropper (quickly worked by foot pressure) like an aerial machine gun.

An anemometer registers the speed of the machine relative to the air, and its indications would be of little value in forming the parallelogram of forces. The speed required is that *relative to the target.*

It is further assumed that it is a simple matter to spot the fall of a shot, and apply the correction resulting from the observation. It must be remembered, however, that the bomb will not strike instantly, and the higher the machine (and

not alarming. The future may, and probably will, witness a wonderful development along this line, but for the present we need not fear such attacks. Occasional raids may be undertaken against unprotected points, but there would be little to gain by such procedure against fortifications, and the probability is that such an expedition would not even be attempted.

Before leaving this subject, I may mention that it has been suggested to substitute for bomb-dropping, bomb-shooting, which seems to be a step in the right direction. By this means, the time of flight would be very much reduced and improved accuracy would result. This method, however, would be applicable to small bombs only; and, as the large bombs are the only ones that will prove of any practical value, the deficiency of the method is manifest.

Where great accuracy of aim is not a requisite, we may expect to find considerable application of a form of bomb-dropping. Such cases would be where incendiary bombs are cast upon a shipyard, store houses, etc.; or where illuminating bombs are employed at night. Here, only approximate accuracy is required. It is probable that such maneuvers will become of greater frequency before the conclusion of the present European War. At any rate, we may expect to find some development in this direction within the near future.

In conclusion, it may be confidently stated that, although bomb-dropping in its present state is very difficult, still, in some of its various forms, it has a good future.

## APPENDIX "B"

### SCOTT BOMB DROPPER

This is a device designed to promote accuracy in the dropping of bombs. Its principle may be stated very briefly as follows:

A telescope is mounted so that it may be rotated about a horizontal axis, and the amount of angular deviation from the vertical is indicated on a graduated scale. Let us suppose that a certain target has been selected. Set the telescope to a position 45° from the vertical in the plane of the path of the machine, which is flying directly toward and over the target. As soon as the target is located in the telescope, its distance from a point directly beneath the aeroplane is known, and is equal to the altitude of the machine as shown by an aneroid. All that is needed, therefore, to determine the actual speed of the craft relative to the earth, is to measure the time required for the machine to travel to a point directly over the target. This is accomplished by setting the telescope for a vertical position and again viewing the target. By referring to a table based upon carefully compiled empirical data, the telescope may be set to an angle such that, when a target appears in the telescope, the bomb may be dropped, and will strike the target.

The success of this device has been moderate, but it evidences careful study of the problem and affords encouragement and hope that future devices of a similar character may have considerably greater accuracy.

## AERIAL PHOTOGRAPHY

The application of photography to aerial reconnaissances is destined to be of inestimable value. An earial observer under the most favorable conditions cannot see and remember all the exact details of a situation; and, even when objects can be seen, he may not have sufficient time to make a close study of details. Thus, a great many points of great value may escape notice. But aerial photography will not miss anything: the whole field can be covered, and a complete record made of all that lies below—a record which can be studied later with close attention.

This method of reconnaissance can be applied to cross-country flights, by means of a series of photographs. By maintaining a constant altitude (by aneroid) all the pictures of the series would have the same scale, and by taking the precaution to take succeeding pictures at short enough interval so as to have adjoining photographs contain a common prominent object, the resulting series can be joined up to form one continuous photograph of the entire route of flight taken. Such a series would require a special camera with long films, sufficient to cover a number of miles of travel, and in addition, a "finder" suitable for the long range work. Of course, telephoto lenses would be employed. This special camera should also be arranged for autographic notes on the pictures, such as is embodied in the most recent types of Eastman Kodaks.

At present, there is no such camera made, but the importance of such a piece of apparatus will undoubtedly appeal to some photographic manufacturer sooner or later, and we can hope for a completely practical instrument to be developed.

### AERIAL RANGE RAKE

This is a device readily constructed at any post, and is designed to aid an observer in spotting for artillery fire. It is also of value in determining distances intervening between any two neighboring points on the ground below.

It is a development of the ordinary range-rake as used in seacoast artillery target practice. Several forms were tried, but as they required special computing rules to be used in conjunction with the readings, they were discarded in favor of the later form shown in the sketch. This device consists of a main wooden staff, A-B, of square cross-section, along which is moved a cross-bar, sliding with friction. The cross-bar carries small pins arranged at regular intervals, an equal number being on each side of a center pin placed over the center line of A-B. An altitude scale, C, is graduated on the

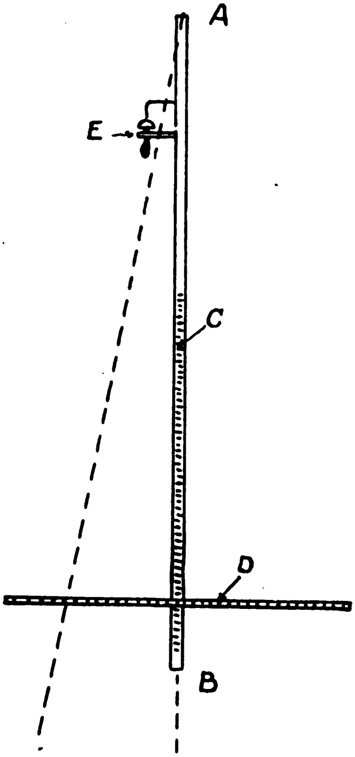


Fig. 2.
Aerial Range Rake

upper surface of A-B, and so marked that when the cross-bar is set at any graduation, one interval between adjacent pins will represent ten yards on the ground, when the bar A-B is vertical. In order to use the instrument for such a condition, the cross-bar would be set to the graduation on C, having the same value as the altitude of the machine as given by the aneroid. Each interval on the cross-bar would then measure ten yards.

But it would rarely happen that either object would be directly below the machine; so we must provide some means for correcting for the obliquity of the line of sight from the vertical. It is evident that this obliquity may be in the vertical plane containing the two objects under observation, or in a vertical plane not containing the two points. This, then, introduces a complex correction.

In order to meet this condition, I have provided a universal level, E, mounted on the side of A-B, near the upper end, A. The upper end of this level is a spherical shell, which moves beneath a small index pointer, and is graduated to indicate "per cent increase" in readings of cross-bar due to the obliquity of A-B. Thus the instrument will give actual distances between two points on the ground from whatever direction viewed. These two points might be the target and the point of "burst" or "fall" of the shot. The application to fire control is obvious.

### RADIO

Reconnaissance by aeroplane requires that information be transmitted as soon as secured, and the means which appear most suited for such communication is the radio; for, while other systems of signaling may suffice for short distances, yet, in general, the wireless telegraph excels. However, the radio equipment is not perfect, since with it communication must be unidirectional—from the machine to the ground; and, though many persons consider this as sufficient, yet the drawbacks are numerous and obvious. Until the aeronautical engine can be completely silenced, there appears little prospect of receiving radio messages at the aeroplane.

Radio equipments for ordinary purposes being too heavy for aeronautical use, persistent and general effort has been made to perfect a light and reliable outfit, and with such success that we have at last secured an equipment with a range of about twenty-five miles which weighs only seventy-five pounds. Its range is ample for all work except strategic reconnaissance and long distance flights generally.

On account of their greater weight carrying ability, dirigibles can be fitted with radio equipments of greater power, and reports credit the latest dirigibles with radio ranges of 250 miles. Dirigibles have the further advantage of being able to receive messages, radio communication having actually been established between dirigibles in flight, a number of miles apart.

### SMOKE SIGNALS

Puffs of lamp black discharged into the air, have been tried as a means of signaling from an aeroplane in flight, the intention being to employ the Morse code or other special system; but the experiments have not been thoroughly successful, since the "puffs" are quickly dissipated by the air currents from the propellers and rendered unintelligible.

### LIGHT SIGNALS

Another method of signaling is by means of a small but brilliant light whose concentrated beam can be directed on any selected point through a sort of diminutive telescopic sight, flash signals being employed. According to newspaper reports, tests of this device have proved its success.

### SIGNALS FOR CONTROL OF FIRE

In communicating with a battery, a spotting aeroplane should be able to supply sufficiently detailed information of the target and fall of shots to enable the fire to be directed with accuracy. The meagre information of "over" or "short" may not be sufficient. In such cases, recourse has been had to "message dropping," for which numerous devices have been suggested, one being a message case containing Bengal fire, which ignites on striking the ground and shows the exact location of the message by the smoke produced. This method is very slow, however.

It would appear, therefore, that the problem of signaling to or from aeroplanes in flight has not yet been satisfactorily solved. The radio offers the best solution, but its unidirectional characteristic is a serious drawback. The problem is one worthy the efforts of our best inventors.

## APPENDIX "C"

### AMERICAN AEROPLANES

The number of American aeroplane manufacturers is very small, and the variety of types of machines, not great. Although a number of companies make and market machines, there are only a few concerns that could be relied upon in case of emergency to produce aeroplanes of suitable types in any number; in fact, for our purposes, the entire American aeroplane industry can be represented by a half-dozen companies, so I have considered it sufficient to make mention of but a few makes. It may be stated, without favor, that the Curtiss Aeroplane Company and the Burgess Company would probably furnish the greater part of our equipment in case of necessity. The Wright Company are now making machines, but their output is small and their type machines are fast becoming obsolete. They might increase their production in case of emergency, however.

### *Curtiss*

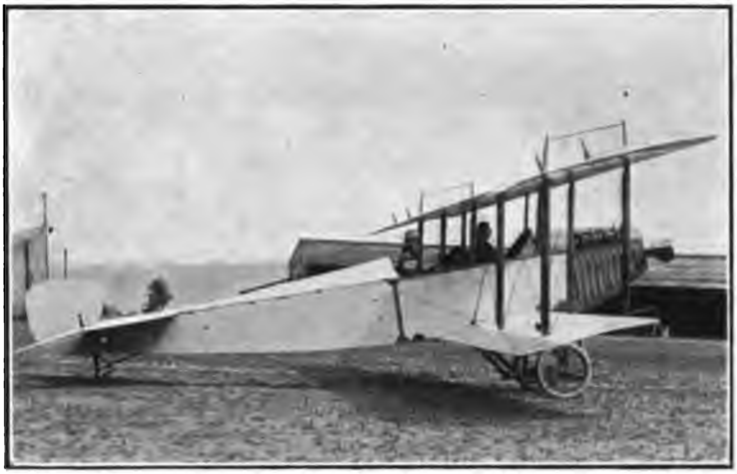
These machines are manufactured by the Curtiss Aeroplane Company, of Hammondsport, N. Y. The regular standard biplanes of this company are well known, and have been very extensively copied by the majority of aeroplane builders in this country.

A detailed description will not be entered into, attention being directed to the accompanying photographs, which show the most recent military tractor biplane developed by the Curtiss company, and the "flying-boat," which was first designed and perfected by the same company. This latter type has been copied in Europe and America, an indication of its efficiency. For naval and coast defense work it is an excellent machine.

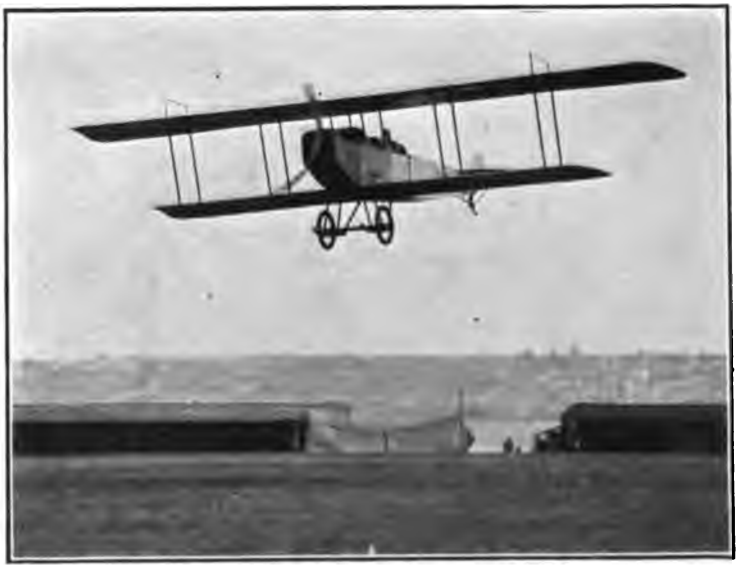
In regard to the military tractor, Mr. Curtiss has had this to say in a letter to me dated Sept. 28, 1914:

> No. 30 has proven very efficient. This speed range is not the limit that the machine will do, and we guarantee a low speed of 40 and a high speed of 90 with two people and fuel enough for five hours. I do not know of any aeroplane abroad which has accomplished this with a 90-h.p. engine.

This machine has succeeded in climbing 1000 feet in one minute, and holds the American altitude record of over 17,000 feet, both feats being achieved under Army aviators.



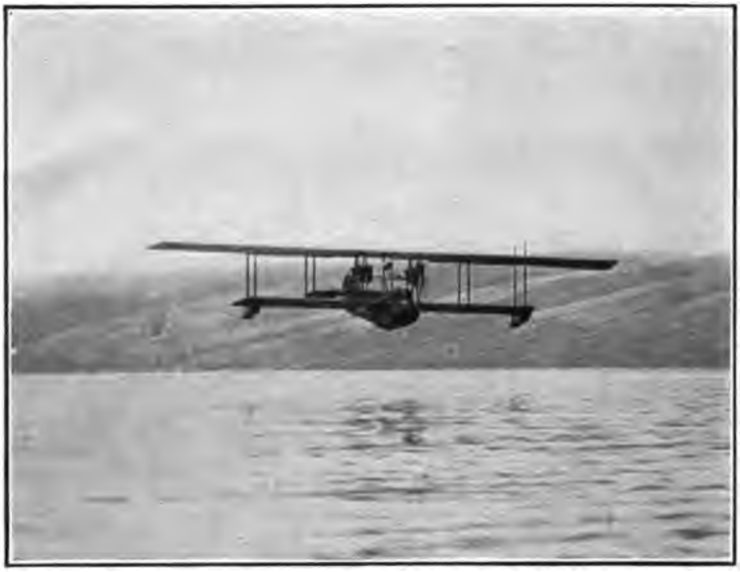
1635



1636

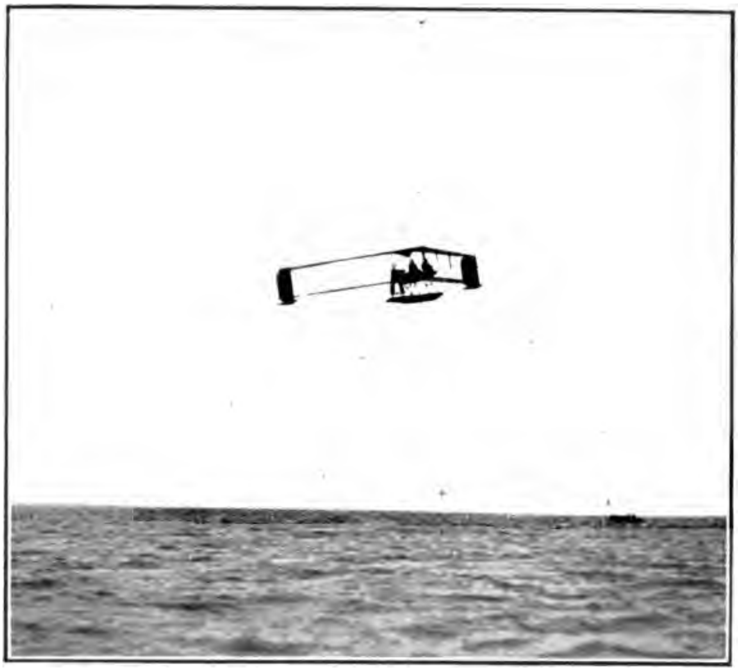
Curtiss Army Tractor No. 30, 1914

Speed variation 40-90 m. p. h.



*Curtiss Aeroplane Co.* 1637

CURTISS FLYING BOAT "AMERICA"



BURGESS-DUNNE SEAPLANE 1638

### *Burgess*

The Burgess Company, of Marblehead, Mass., have developed and placed upon the market the Burgess-Dunne aeroplane. This machine is a great departure from the usual forms of aeroplanes, as can be seen from the photograph. The wings slope backward from the center, forming with each other a considerable angle, in which the propeller is located; no "tail" is present; the control is through the ailerons alone. Pilots who have flown this machine speak highly of its stability and ease of control. The manufacturers claim for it superiority over other types and a greater *inherent* stability, as distinguished from manual and mechanical control.

### *Aircraft Company*

The Aircraft Company (which has succeeded the Sloane Aeroplane Company) produces two types of monoplanes for military purposes, and a "flying-boat" of the usual type. The company make the following remarks in regard to their machines:

> The Model "D" and "D-2" Monoplanes, are easily set up and dismantled and can be transported on their own wheels.
>
> The model "D-2" is arranged for pilot and observer seated in tandem, and is equipped for either double or single control. It is equipped with either an 80 or 100-h.p. rotary air-cooled Gyro Motor, or other engine of like horse-power. It has a flying range of from forty-five close on to ninety miles an hour. With full load for four hours and two men aboard, its guaranteed speed range is from forty-six to eighty miles per hour. Its guaranteed climbing speed is 2000 feet in six minutes.
>
> The Model "D" Sloane Monoplane is a single-seater, fast scout. Equipped with a 100-h.p. Gyro Motor, the Model "D" has a flying range of fifty to ninety-five miles per hour and a speed range, with full load four hours fuel, of fifty to eighty-seven miles per hour. With full load its guaranteed climbing speed is 400 feet per minute.
>
> Cost, f. o. b., New York:

| | |
|---|---|
| Model "D" and "D-2".......... | $7000 |
| Hydro equipment, extra......... | 550 |

### *Schmitt Monoplane*

Another American built monoplane is the Schmitt, manufactured in Paterson, N. J. The manufacturer's catalogue states as follows:

> The Schmitt Monoplanes are made in several models. The single-seater, Model A; the passenger carrying monoplane, Model B; and the armored military monoplane which carries a quick firing gun. These three models can be furnished to fly from and alight on water as well as on land.

One of the peculiar advantages that the Schmitt Monoplanes possess, is the changeable wing-angle device, which permits the monoplane to change its speed while in flight from 45 to 75 miles an hour.

The Schmitt Monoplanes can be equipped with motors of 50 to 200-h.p. or more. When equipped with 50 or 80-h.p. motors, the single-seater monoplane will develop a speed of 75 and 100 miles respectively; and the passenger carrying monoplane equipped with the same horsepower will develop speed 60 to 90 miles an hour.

### *Heinrich Monoplane*

This is another American built monoplane, and is manufactured in Baldwin, L. I. Its accomplishments are average practice. An 80-h.p. motor furnishes its power.

### *Thomas*

The Thomas Brothers' Aeroplane Company, of Bath, N. Y., manufacture biplanes conforming to usual practice. They build a flying-boat also.

### *Benoist*

The Benoist Aircraft Company, of St. Louis, Mo., are the builders of an air-boat that has a good record. The maker's catalogues state as follows:

> Nearly all airboats built in this country or Europe appear to have the same general characteristics; this being noticeable in the shape of the hull, position of the motor, placing of pilot and passengers, and many other points too numerous to mention; the only exception being in the Benoist.
>
> One of the most noticeable improvements in the Benoist over other machines is the placing of the motor in the hull of the boat and driving the propeller by a chain transmission.
>
> Type 14, Benoist Airboat—
>
> Model A:
>
> *Capacity:* Two-place, seats aviator and passenger.
> *Motor:* Seventy-five horse-power.
> *Speed:* Sixty miles in air, fifty miles on water.
> *Price:* $4500.00 complete with equipment, consisting of tools and extra propeller.
>
> Model B:
>
> *Capacity:* Four-place, seats aviator and three passengers.
> *Motor:* One hundred horse-power.
> *Speed:* Sixty miles in air, fifty miles on water.
> *Price:* $7500.00, complete with equipment, consisting of tools and extra propeller.

## NOTE

## COMPARISON OF MOTORS*

| Motor | Wt. (net) | Gals. Gas per hr. | Gals. Oil per hr. | Fuel, Wt. 4 hrs. | Total Wt. Motor and Fuel | Wt. per h.p. For 4 hrs. |
|---|---|---|---|---|---|---|
| | lbs. | | | lbs. | lbs. | lbs. |
| 100 Gnome......... | 308.64 | 12.17 | 2.70 | 377.76 | 686.4 | 8.07 |
| 70 Renault......... | 462.97 | 9.26 | .79 | 246.03 | 709.0 | 9.95 |
| 90-100 Curtiss....... | 430.00 | 8.00 | .50 | 208.00 | 638.0 | 7.51 |

* From *Aeronautics*, November, 1913.

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# FORMS FOR RECORDS OF MINE PLANTING

Captain Paul D. Bunker, Coast Artillery Corps, has prepared for the use of both commanding officers of mine-planters and commanders of mine companies, the forms for mine-planting records presented herewith.

Captain Bunker acknowledges indebtedness to forms prepared by at least one mine-planter commander, but claims for the forms prepared by him the advantages of such arrangement of data that the data are recorded during the actual progress of the work and simultaneously by different chiefs of detachment.

Captain Fulton Q. C. Gardner, Coast Artillery Corps, has suggested that, to be complete, forms for the loading room, the store-room, and the planter, respectively, should include the following data:

*Loading Room*

(a) Serial number of mine as assembled.
(b) Size case.
(c) Kind of plug used.
(d) Kind of explosive used.
(e) Kind of primer used.
(f) Per cent moisture in charge.
(g) Per cent moisture in primer.

*Storeroom*

(a) Kind of mooring rope or chain.
(b) Size of mooring rope or chain.
(c) Method used for attachment of mooring rope to drum.
(d) Kind of distance line used.
(e) Size of distance line used.
(f) Method used for attachment of distance line to pawl.

*Planter*

(a) Serial number of case.
(b) Serial number of anchor.

(c) Raising rope attached to anchor where?
(d) Length of mooring rope out of anchor.
(e) Time of fall of anchor (time between instant anchor strikes water and instant mine is drawn under the surface.)
(f) Velocity of tide.
(g) Actual length of buoy rope.
(h) Length of mooring rope used (for mushroom anchor).
(i) Kind of mooring rope used (for mushroom anchor).
(j) Kind of bottom.

Captain Gardner adds:

"(a) Separate records should be provided each for the storeroom, loading room, casemate, and planter.

"(b) Since, in service, and in instruction, especially where more than one mine company is under instruction, the operations in the storeroom especially and, to perhaps a somewhat less degree, in the loading room also, must practically be continuous, it is not necessary or desirable, in the general case, to attempt to keep the records in the storeroom and in the loading room in such a manner that the data pertaining only to those mines or anchors which are finally planted in a particular serially numbered group shall appear on the same sheet. Thus it has been found that, especially in instruction work where groups are planted and raised daily by one detail, while other groups for planting on the succeeding day are at the same time being prepared on shore by another detail, it will not be desirable or practicable to use all the five, seven, or nineteen anchors, as the case may be, which were assembled in sequence, and no others, in any particular group of mines.

"(c) My experience has indicated that the most satisfactory system of keeping the records herein referred to, is for a separate note book of the type regularly issued for the purpose, to be furnished each to the storeroom, loading room, and to the planting officer. Each anchor and mine is given a serial number as assembled and the complete data is recorded for each separate one assembled, this record being in a continuous form shown separately for each date. Upon the completion of each day's work the planting officer, or the planter commander, collects the books from the loading and store rooms, and tabulates in his own book the data desired corresponding to the serial number of the mine and anchor, this serial number being noted during the time the anchor and mine are being assembled on the planter.

"(d) By this method, using a double page of the note book, and using a horizontal line for each mine or anchor, the full data relating to approximately twenty-five anchors or mines can be recorded without turning the page."

Planter..............................................

..........Co., Fort............................ Date..............

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group and Mine Nos. | | | | | | | | | | |
| Transformer No. | | | | | | | | | | |
| Transformer | Black wire disconnected from stud | Thro' Black[1] | | | | | | | | |
| | | Black and Case | | | | | | | | |
| | | Black and Stud[2] | | | | | | | | |
| | | Black and Red | | | | | | | | |
| | | Red and Red | | | | | | | | |
| | | Red and Case | | | | | | | | |
| | Connected | Black and Case | Vert.[1] | | | | | | | |
| | | | Tip.[3] | | | | | | | |
| Plug | | Vertical | | | | | | | | |
| | | Tipped | | | | | | | | |
| E. M. F. of battery | | | | | | | | | | |
| Mine | First Test | Vertical | | | | | | | | |
| | | Tipped | | | | | | | | |
| | In tank, hours | | | | | | | | | |
| | Last Test | Vertical | | | | | | | | |
| | | Tipped | | | | | | | | |
| E. M. F. of battery | | | | | | | | | | |
| | | | | | | | | | | |
| Kind of fuse can | | | | | | | | | | |
| Circuit closer clean? | | | | | | | | | | |
| Springs good? | | | | | | | | | | |
| Who assembled plug? | | | | | | | | | | |
| Who assembled mine? | | | | | | | | | | |

Resistance of voltmeter used in plug test:.......... In mine test:........

Commenced loading..........1st plug loaded by......................

at..........Last plug loaded at..........1st mine ready at............

Last mine ready at............

.................................Chief Loader.

Calculate resistances in case of suspicious readings only: [1] should be about 2400 ohms, [2] about 130 ohms and [3] about 120 ohms.

$\text{Resistance} = \text{Resistance of voltmeter}\ [(\text{E.M.F.} \times \text{Reading}) - 1]$

Put remarks on back of this sheet.

Planter........................................

..........Co., Fort.......................... Date................

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Group and Mine Nos. | | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Planting | | Heav. Line... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Mine Drop'd . | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Raising | | Heav. Line... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Mine in...... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Feet | | Tide ........ | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Submergence . | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Sounding..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Man responsible for insulation of | | Mine joint.... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | D. B. joint... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Cable ends... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Results of tests | Mult. cable | Before plant. . | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | After planting | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | Air test...... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | Wet mine test....... | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | Wet box test........ | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Planter's speed, knots.......... | | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ........................ | | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ........................ | | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

Officer in charge...................... Ass'ts and observers...........
Casemate voltage....... Electrician..................................
Co. arrived at wharf..... Commenced loading planter at......Finished at........ Left wharf for..........mine field at........ Arrived at mine field at........ Returned to wharf.............................
Remarks..........................................................

| | |
|---|---|
| ................................ | Prick thro' the plot of the group into this space....................... |
| ................................ | .................................... |
| ................................ | .................................... |
| ................................ | .................................... |
| ................................ | .................................... |
| ................................ | .................................... |
| ................................ | .................................... |
| ................................ | ..............+Distribution box. |

Planter........................................

..........Co., Fort............................ Date................

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Group and Mine Nos.......... | .... | .... | .... | .... | .... | .... | ..... |
| Anchor No................. | .... | .... | .... | .... | .... | .... | ..... |
| Weight, lbs................. | .... | .... | .... | .... | .... | .... | ..... |
| Drum adjust., lbs. ............ | .... | .... | .... | .... | .... | .... | ..... |
| Spring adjust., lbs. ........... | .... | .... | .... | .... | .... | .... | ..... |
| Mooring rope, ft.............. | .... | .... | .... | .... | .... | .... | ..... |
| Dist. wt. rope, ft............. | .... | .... | .... | .... | .... | .... | ..... |
| Lead dist. wt., lbs............ | .... | .... | .... | .... | .... | .... | ..... |
| Anchor adjusted by.......... | .... | .... | .... | .... | .... | .... | ..... |
| ........................ | .... | .... | .... | .... | .... | .... | ..... |
| ........................ | .... | .... | .... | .... | .... | .... | ..... |

SINGLE CONDUCTOR CABLES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Length, ft.................. | .... | .... | .... | .... | .... | .... | ..... |
| Test for open circuit.......... | .... | .... | .... | .... | .... | .... | ..... |
| Test for grounds............. | .... | .... | .... | .... | .... | .... | ..... |
| Battery E. M. F.............. | .... | .... | .... | .... | .... | .... | ..... |
| Tested by................... | .... | .... | .... | .... | .... | .... | ..... |
| ........................ | .... | .... | .... | .... | .... | .... | ..... |

Property lost, Remarks, etc.,..................................

.......................................................

.......................................................

.......................................................

.......................................................

.......................................................

the battery. The firing circuit being closed, the electric current fires the detonator, exploding the mine; a slight delay is thus obtained between the actual impact against the mine and the firing of it.

Rule VIII, Article 1, par. 2, of the Hague Convention, 1907, states:

> It is forbidden to lay anchored automatic contact mines which do not become harmless as soon as they have broken loose from their moorings.

The device on the German mine that clamps the mooring rope, is released when the tension on the mooring rope is removed. The device also contains part of the firing circuit which is opened when the tension on the mooring is removed. Thus a floating mine is harmless, having an open firing circuit.

### RAISING THE MINES

Most types of naval defense mines employ a series cable connecting the anchors of a string of mines. By pulling in on the series cable, the anchors are raised one by one, and the mines rise to the surface and are recovered. This method of raising mines becomes rather dangerous in rough water, and is regarded unfavorably generally by all naval authorities. The Germans have provided a system of tripping cables which does away with the danger to a large degree. One anchor is connected to the next by a tripping cable. A pull on this tripping cable releases a bight in the mooring rope, allowing the mine to rise to the surface. This action makes the mine harmless. As an additional precaution for safety in raising the mine from the surface of the water, a loop of wire in the firing circuit is placed at a convenient place outside of the mine case. This loop is cut with a pair of pliers before the mine is touched; then the mine can be raised to the planter; the men are sure that the mine is harmless.

The relative advantages of this mine over the Elia mine and the Sautter-Harlé mine have been summarized as follows:

### *Advantages*

1. Speed of planter of no consequence. These mines will always function properly, since the tumbling of the anchor and improper operation of the distance weight are eliminated. They may be thrown into the water upside down, and they will function properly.

[illegible]

[illegible]

2. Will operate in shallow water where the other mines will not function properly. By shallow water is meant a depth of not less than twenty-five feet.

3. Positive mooring of the mines. During the last two months several hundred British and French mines have been washed ashore on the Holland coast; only two German mines have been reported as washed ashore. The anchor is very heavy, and dragging of the anchor will not release the mooring rope.

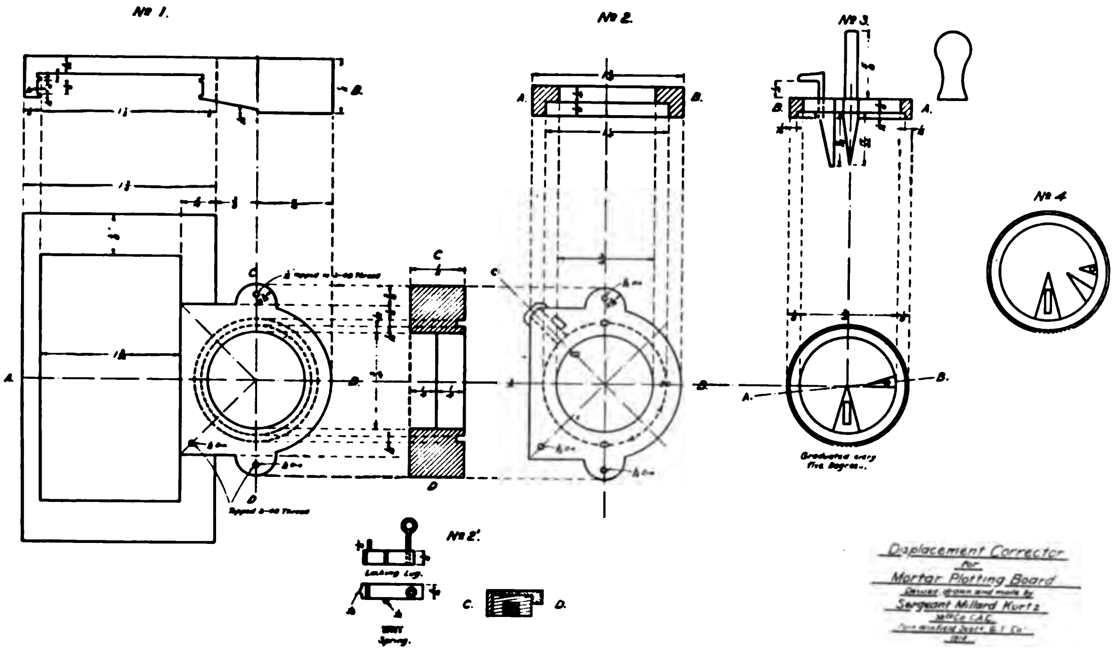
4. Can be taken up with perfect safety, if the tripping cables are used.

5. Wave action or countermining cannot tip the mine and explode it.

6. Fewer floaters and sinkers. The transfer of the mooring rope reel from the anchor to the mine, gives more time for the operation of the automatic submergence device, and this insures a higher efficiency for the device. Conditions of speed of planting, and of the surface of the water do not enter into the conditions affecting the operation of the device.

The electric features of this mine are similar to those of the Russian electric and mechanical mine described on pages 8 and 9 of the Journal for July-August, 1914.

[illegible]



1641

No. 1.—The main body shown in both planes, together with a cross section.

No. 2.—The cover for the pointer rack. No. 2'. The locking lug, together with a sectional view of the recess in which it works.

No. 3.—The pointer rack for use in the case of batteries for which the azimuth setting for the battery commander's instrument can be obtained by means of the primary arm.

No. 4.—A suggestion for the arrangement of pointers for use in the case of batteries for which the azimuth setting for the battery commander's instrument cannot be obtained by means of the primary arm. The pointer for the second pit has no indicating pointer on top of it. The pointer for setting the rack can be placed upon the third, or battery commander's, pointer, thus giving a clear field. The indicating pointer is bent so as to have the second pointer parallel with the edge of the gun arm, thereby keeping the zeros of the numbers on the pointer rack even in line with the edge of the mortar arm.

The rack revolves in a case which is graduated at every 10-degrees from 90 to 0 in both directions; *i.e.*, clockwise, and contra-clockwise. The 90-degree mark is at the point where there is the *maximum azimuth* difference and *no range* difference. The zero graduations lie along the fiducial edge of the mortar arm; so, with a setting of zero, both pointers lie in the same line and both pits will receive the same azimuth, while there will be the maximum *range* difference.

A spring clamp retains the circular rack at its proper setting, and permits the movement of the "B" pit pointer around the "A" pit pointer (the latter being in the center of the rack).

## TO USE THE CORRECTOR

Set the mortar center of the plotting board over the center of "A" pit.

Set the mortar arm at the azimuth of the pit displacement and draw a line in the field of fire on the plotting board; this line is called the zero line.

Move the mortar arm through five-degree intervals, both plus and minus, and draw direction lines, marking them 5, 10, etc., to 90, so the plotter can see them, for use in setting the spring clamp of the circular rack when tracking.

When plotting, the plotter observes in which sector the next set-forward point is to fall, and sets the spring clamp to the sector degree setting. He is then prepared to send correct readings for either pit.

If the directing point is in front of the other pit, the clockwise graduation of the circular rack will be used; if behind, then the contra-clockwise graduation.

# COAST ARTILLERY WAR GAME MATERIAL

By Captain VERNON W. HALL, Coast Artillery Corps,
N. G. State of Maine

The Coast Artillery War Game board built by the Maine Coast Artillery Reserves in the Armory at Portland, contains a few departures from the methods laid down in the War Game pamphlet, making for economy and ease of construction, without sacrificing appearance or utility.

## Land Features

The building up of the land features approximated the "paper pulp method" outlined in the May-June, 1914, number of the Journal of the U. S. Artillery, with the exception that the material used was asbestos cement, permitting greater accuracy in following the contours and necessitating practically no allowance for shrinkage.

An enlarged contour map of the Coast Defense of Portland, scale 100 yards to the inch, having been drawn on the board, brads and small-finish nails were driven on the contour lines, spaced not over an inch and a half apart, to heights appropriate to each contour on a vertical scale of 100 feet to the inch. A vertical scale of 60 feet to the inch was suggested and tested, but it was found that the distortion was abnormal, and that a vertical scale three times the horizontal scale produced more natural results.

A mixture of about four parts pulverized asbestos to one part Portland cement, mixed rather thickly with water, was then spread on, worked in freely with trowel and wooden paddles round the brads, which furnished accurate elevation points, and finished off, not too smoothly, with the hands. No tools seemed to give such finished effects as could be secured with the hands, particularly around the shore lines, which, in a coast defense like Portland with its multitude of islands, furnished the only difficult part of the work. The contours could be followed readily, with an occasional glance at a map, taking care not to tear the hands on the nail heads. It was found necessary to sketch in the shore line with waterproof India ink and a small brush, before building up, as ordinary marks were liable to be erased in working the cement back and forth over the line, as was usually necessary before accurate results were secured. The modeling went off quite rapidly, once all preparations were made.

Asbestos cement was chosen for the land features because the fibrous nature of the asbestos gave a slightly roughened aspect to the completed board, which lent a natural appearance, while the cement aided in hardening it up. The brads not only gave elevations, but reinforced the mixture and produced a perfect bond with the board. Several variations in proportion were tried, but four to one worked out best. Too much asbestos produced a considerable amount of shrinkage in drying, and parts built in this manner had to be refinished to bring them up to elevation. Too much cement gave too smooth an appearance. The final mixture, however, was about ideal, and the land features could be finished down to just cover the elevation points, where they dried with practically no shrinkage. The mixture hardened over night and thoroughly dried out in four or five days.

The Portland board is located permanently and is not designed to be moved. It is probable, however, that where boards have to be taken apart, the entire map could be built and sawed apart at the table joints.

Emplacements were modeled out of cement, mixed very thickly, and bonded to the land features before the latter hardened. Asbestos could not be used in the emplacements, as the fibers prevented fine modeling. Guns were represented by bits of wire, appropriately bent and imbedded in the emplacements. Stations and coast defense elements, with a few of the more prominent landmarks, were cut out of wood and stuck in the cement while still plastic. Lighthouses were made of 3/16-inch screws, set in to proper height, with the heads cut off, filed round and properly painted. There is no danger of the "Navy's" knocking over these lighthouses in moving round the board.

Fields, roads and streams were, of course, painted, when the board was dry, while woods were represented by steel wool glued in proper locations and painted.

## WATER AREA

To make the water area perfectly smooth, the table was carpeted with light duck, cut out and tacked round the shore line and painted. (A better method would have been to put on the canvas first and build the land upon it, but the carpet was an afterthought.)

Range arcs were drawn in different colored inks from the several forts, doing away with range tapes, which continally get in the way of searchlight beams during night phases.

### SEARCHLIGHT

There was developed by the artillery engineer and an electrician sergeant a simplified and improved searchlight, which can be built by any good mechanic, without a lathe, from stock material, at a cost of about one dollar and sixty cents for stock and not more than a day's time for labor. Each light is operated from the side of the board by two controllers, one for traversing and the other for elevating and depressing. The mirror is hinged at the lower end and the inclination can be varied through some 75 to 80 degrees elevation by a sliding collar and arm. The light can be occulted by lowering the mirror to a horizontal position. This does away with the necessity of having a switch for each light, reducing the cost of installation. One switch turns on all the lights on the board, which are put in action or occulted by raising or lowering the mirror.

All the work on the board, the searchlights, the fleet, and the accessories was done by the officers and enlisted specialists of the Maine Coast Artillery Reserves.

# A MINIATURE ARDOIS SET

### By 1st Lieutenant D. N. SWAN, Jr., Coast Artillery Corps

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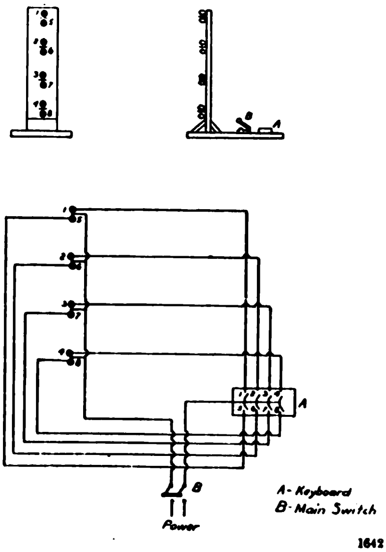
The illustration herewith represents a miniature Ardois set of which the following is a description:

Mounted on a one-inch board of eight inches width, are eight four-candle power lamps, arranged in groups of two, one red and one white, the red being above the white, and the groups being separated by about ten inches. Between the red lamp and the white lamp of each group is a small tin shield painted dull black, to prevent the red's being shown when the current is on in the white.



The lamps are connected in parallel to a board with eight push-buttons arranged in two rows, the upper row controlling the red lamps and the lower row the white lamps, as shown in the wiring diagram. The red lamps representing dots and the white lamps dashes, to signal the letter *a* push *1* and *6* simultaneously; to signal the letter *f*, push *1*, *2*, *7*, and *4;* etc. Nos. *1*, *2*, *5*, and *6* are operated with the left hand and Nos. *3*, *4*, *7*, and *8* with the right. A 10-volt lighting circuit is used.

## JOURNAL UNITED STATES ARTILLERY
## PRIZE ESSAY COMPETITION

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### 1915

The Journal U. S. Artillery announces the following for its annual competition:

1. One hundred dollars for the best essay submitted on either subject named, as determined by the Committee of Award, except as provided under condition (b).

2. Seventy-five dollars for the best essay, determined as above, on the other subject named—that is, on the subject not discussed in the essay to which the first prize is awarded—except as provided under condition (b).

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### SUBJECTS

*A. Preparations that should be made in peace for quartering and provisioning coast defense garrisons in war.*

*B. Effect upon measures for coast defense of the development of submarine and aerial attack.*

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### CONDITIONS OF THE COMPETITION

(a) Competition will be open to all readers of the Journal.

(b) Award will be made by a committee of award, consisting of three persons, to be nominated by the Coast Artillery School Board. If no essay submitted seems to the committee worthy of a prize, none will be awarded. If it appears to the committee that no essay fulfills the conditions for the second prize, but that another essay upon the same subject as that of the first prize essay is worthy of the second prize, they may award the second prize to that essay. Honorable mention may be made of any essay submitted which seems to the committee worthy thereof, but to which a prize is not awarded.

(c) All essays to which prizes are awarded, or of which honorable mention is made, will become the property of the Journal of the United States Artillery. These will be published, if approved by the Coast Artillery School Board. All others will be returned to their authors.

(d) Copy must be typewritten, with lines double spaced, on one side of the paper only, and must be submitted in triplicate. No essay shall contain more than 15,000 words, exclusive of tables (about 40 pages of the Journal). If illustrations are included, one of the three copies thereof must be in the form of drawings, tracings, or photographs (not blue-prints nor brown-prints).

(e) Copy must contain nothing to indicate its authorship, must be signed with a *nom de plume*, and must be accompanied by a sealed envelope containing this *nom de plume* and the name of the writer. This envelope will remain in the hands of the Editor of the Journal and, after award has been made by the Committee, will be opened in the presence of the Coast Artillery School Board.

(f) Copy must be received on, or before, December 31st, 1915. It must be addressed Journal U. S. Artillery and the envelope must bear the notation, "Essay Competition."

## The Library of the Coast Artillery School

is now prepared to accept books or collections of books, either as loan or gift. The new building is fire proof and the best of care will be accorded any works entrusted to the Library.

It will be glad to have any copies of the JOURNAL OF THE U. S. ARTILLERY, or any copies of ARTILLERY NOTES, which their possessors do not desire to keep.

# PROFESSIONAL NOTES

## COAST DEFENSE ARMAMENT AND ITS EMPLOYMENT IN REPELLING THE ATTACK OF A MODERN FLEET[*]

By Captain Renzo Garrone, Italian Artillery

Translated from the German for the Journal of the U. S. Artillery by 2nd Lieutenant Donald Armstrong, Coast Artillery Corps[†]

### Foreword

The battleship, against which the power of coast batteries should be measured, is constantly attaining a more effective form; though the process of evolution is accomplished, under normal conditions, very slowly, based as it is on theoretical speculation, uncorroborated by experience of war, a step in advance being taken only when convenience makes it indispensable. Thus was observed the evolution, model by model, of the battleship of 1905. On the other hand, from the battle of Tsu-Shima, naval engineers deduced new lessons, perhaps too precipitately, especially as regards armament; and in 1906 appeared the *Dreadnought*, which revolutionized naval construction.

From the introduction of the *Dreadnought* to to-day seven years have passed, and if we review that period carefully, we become convinced that the theories originally founded upon the experiences of the Russo-Japanese War have lost, in great measure, their finality. Indeed, there is not much risk to-day in predicting that some of the characteristices of the *Dreadnought* and its immediate derivatives will perhaps some day represent only a perenthetical phase in the evolution of the offensive power of the battleship.[‡]

This brief summary of the contemporaneous evolution of naval construction is sufficient to indicate the conditions which are met with to-day in a study of the artillery defense of a fortified point of a coast line. For comparison with homogeneous squadrons of dreadnoughts, it would be simple to determine defensive types of armament and the proportions to be maintained between the various types, but in existing fleets a large number of units antedate 1905, and before they disappear, by reason of being obsolete, perhaps the new battleship will have so closely approximated their type as to be a substitute for them in the attack. So it is evident that we cannot, in our study of defensive measures, omit this second type of ship, the armament of which, as we shall see, has great value in attack on batteries without overhead cover.

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[*] Captain Garrone's essay, which was awarded the gold medal by the *Rivista di Artiglieria e Genio* for the year 1913, is undoubtedly the best discussion written in recent years on a subject on which opinions are so divergent as they are on coast artillery.—*Translator from Italian to German.*

[†] In preparing the article in the form in which it is here presented, the Editor has made use, not only of the translation from the German by Lieut. Armstrong, but also of a translation from the Italian by Captain George A. Wieczorek, C. A. C., which was furnished through the courtesy of the War College Division of the General Staff.

[‡] The medium caliber has been placed on board again—under the name of anti-torpedo boat armament, it is true, but still in numbers so considerable that it represents an offensive factor that is not to be neglected, at least for the purpose of our discussion; nor is it by any means certain that the increase in power of the armament will stop at the 6-inch caliber. Consequently, it appears that the battleships of to-day are not very different from the pre-Dreadnoughts in the proportion existing between the various elements: a nearly doubled displacement is accompanied by greater vertical protection, greater speed, and an artillery proportionally augmented in the various calibers.

Passing from general considerations to lay the woof of what is to be a detailed study of armament, it is readily seen that the study of defensive armaments should follow studies of the means of attack and defense of the various types of ships opposed to the batteries; for the ships, availing themselves of their privilege of choosing the battle range and form of attack, will proceed in the manner best calculated to afford them the greatest advantages and smallest disadvantages: consideration of ships' armaments will enable us to discover the principles governing the choice of a gun for coast defense, the characteristics of the two being similar by reason of their having a common object.

After a study of both a coast gun and a coast howitzer or mortar, an attempt will be made to establish some standard for determining the proportion between the various types of armament, having in mind the different cases that may arise in the organization of the defenses as a result of the variety of objects for which the organization may be intended. Finally, the action of batteries in repelling the attack of a fleet will be touched upon.

### THE PRE-DREADNOUGHTS

On ships constructed before 1898, which are now about to disappear from fleets in commission, the heavy armament was represented by four guns of major caliber; the intermediate armament by about a dozen 6-in. guns; and the anti-torpedo armament by guns of still smaller caliber. In naval combat the artillery action was sustained principally by the medium caliber guns, the large guns being reserved for the last stage of the engagement; and, in consonance therewith, the armor on the greater part of the protected area was designed to resist attack by the 6-inch projectile, and so consisted of plates of rather limited thickness. Displacements also were small, being about 11,000 tons.

The employment of ever increasing side armor, resulted, in time, in rendering the 6-inch caliber too small; so between 1898 and 1905 the medium caliber armament is seen steadily to increase in power from the 6.38-inch of the French *Suffren* to the 9.2-inch of the English *Lord Nelson*.* Toward

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*The first increase of the medium caliber was made in 1898 in the case of the French ship *Suffren;* though, it is true, Italy, at about this time, placed aboard the sister ships of the "Benedetto Brin" type four 8-inch guns besides four 12-inch guns. But this armament, like that of the "King Edward" class (four 9.2-inch guns), the *Iwami* (six 8-inch), and the *Kashima* (four 10-inch), is rather to be considered supplementary of the primary armament, because of the small number of such pieces aboard each ship.

Of vessels of this class may be mentioned:

| | |
|---|---|
| In England, | |
| *Swiftsure* and *Triumph* | fourteen 7.5-inch guns. |
| "Lord Nelson" class | ten 9.2-inch guns. |
| In Germany, | |
| "Braunschweig" class | fourteen 6.7-inch guns. |
| *Deutschland* | fourteen 6.7-inch guns. |
| In France, | |
| *Suffren* | ten 6.5-inch guns. |
| "Republique" class | eighteen 6.5-inch guns. |
| "Verite" class | ten 7.6-inch guns. |
| "Danton" class | twelve 7.6-inch guns. |
| In the United States, | |
| "New Jersey" class | eight 8-inch guns. |
| "Louisiana" class | eight 8-inch guns. |
| "Idaho" class | eight 8-inch guns. |
| "Kansas" class | eight 8-inch guns. |

the end of this period the medium caliber generally adopted was between 7.5 and 8 inches, with muzzle velocities of from 2780 to 2950 f.s.,[*] the number of guns on each ship varying from eight to fourteen, and the guns, though occasionally in batteries, yet as a rule mounted in turrets with large sectors of fire. Besides an increase in thickness of armor, which became as much as twelve inches at the middle of the belt and on the turrets, the ships of this period had greater speed and greater displacement than their predecessors, the displacement averaging 15,000 tons.

Although the increase in caliber of the intermediate armament had its origin in the requirements of naval combat, yet it greatly increased the efficiency of the ships in attack on coast fortifications and enabled them to open fire at greater range. As regards the increased efficiency against fortifications, it is to be noted that in this type of ship was established a logical proportion between the means of defense on land and the means of attack by sea, since to the few armored works on land[†] there was opposed a limited armament of major caliber aboard ship, while for action against the numerous unprotected works on land there was provided a numerous intermediate armament of increased caliber, which was better suited for the purpose. Indeed, against barbette batteries protected by shields and against indirect fire batteries, the 12-inch gun cannot be advantageously used, because its rapid erosion[‡] and limited supply of ammunition preclude the long and sustained fire which is necessary to silence the defense; while, on the other hand, the 7.5-inch and the 8-inch calibers are well suited for this work, by reason of their power, their large numbers aboard ship, their accuracy life, and their precision of fire.

The semi-armor-piercing shell of about 220-lbs. weight with a bursting charge of about 15-lbs. of trotol, is effective against even very thick shields and is also most effective in the destruction of concrete parapets. It explodes only after perforation, even though fired with the battering charge.[‖]

As already stated, the number of medium caliber guns varies from eight to fourteen, usually placed in turrets; and, as a result of the extensive sectors of fire possible with this arrangement, these guns can fire at least

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[*] The characteristics of the guns in question are given in the following table:

| Nationality | Caliber in. | Length cal. | Weight of projectile lbs. | Muzzle velocity ft. sec. | Shots per minute |
|---|---|---|---|---|---|
| English.......... | 7.5 | 50 | 200 | 2788 | 2–3 |
| | 9.2 | 50 | 380 | 2788 | 2 |
| German ......... | 6.7 | 40 | 132 | 2886 | 5 |
| French.......... | 6.5 | 45 | 115 | 3017 | 4–5 |
| | 7.6 | 45 | 185 | 3120 | 2–5 |
| American........ | 8.0 | 45 | 260 | 2755 | 2 |

[†] It must be realized that, in fortifications, the means of protecting batteries employed aboard ship, can, for reasons of economy, be used only in the case of those guns that must be left undamaged for use in repelling a run-by. The other guns, the majority, cannot be afforded that means of protection, but must depend upon ordinary concrete parapets and shields, where the type of gun and the character of the coast do not permit indirect fire or masked emplacements.

[‡] One 12-inch, 40-caliber gun after 43 shots with battering charge, 3 with increased charge, and 17 with full charge, had its rifling entirely eaten away over 40 cm. of the length of the bore.

[‖] If less penetrating power and greater explosive force are desired, it is possible to use a lighter projectile with a smaller propelling charge. For such a projectile the bursting charge would be of from 26 to 29 lbs., and therefore not much inferior to the Italian 8.25-inch mortar shell.

four medium caliber guns ahead or astern, and the same number on a broadside, though in some cases six are available on a broadside. In no case is more than half the armament in action at the same time, which is a limitation that is convenient in prolonged action against fortifications, since it tends to preserve the bores of the guns. A long series of successive shots from a heated bore is far more hurtful than an equal number of well separated shots.

As regards accuracy of fire, it is observed that at the normal fighting range (5500 yds.) the vertical 50 per cent zone has a height of 11.5 ft.* It may be added that the displacement of the type of ship in question is a factor for accurate shooting, since the gun platform is steadier.

When, from battle efficiency against batteries, we pass to a consideration of long range fire, such as is involved in the bombardment of relatively large areas, this caliber presents qualities that have been already mentioned as lacking in the 12-inch—accuracy life and supply of ammunition—as well as other qualities particularly applicable to the use now considered, such as a balance between the power of the projectile and its ranging ability, and, as compared with the 6-inch and smaller calibers, visibility of the fall of shots, when the sea is rough or the atmosphere hazy. The visibility of burst in the case of the 7.5-inch and 8-inch guns, then, is good; the guns suffer little from prolonged fire, as compared with the 12-inch; and their accuracy of fire is sufficient to place all their shots, at a range of 13,000 yards, in a zone of 545 yds. depth. Accordingly, the bombardment of a fort, an arsenal, or a town, when the results practicable in such undertakings are taken into consideration, will be most efficiently accomplished by guns of this caliber.

## THE DEVELOPMENT OF NAVAL ORDNANCE AND CONSTRUCTION FROM 1906 TO THE PRESENT

As a result of the experiences of the Russo-Japanese War, England, in 1906, built the *Dreadnought*, from which has been taken the name of the modern type of battleship. Its principal characteristic was a revolution against previous practice, in that the burden of battle was placed upon the guns of major caliber, of which the number was successively fixed at eight, ten, and twelve, at the expense of the intermediate armament, which was omitted. This radical departure was based on the following reasons: (1) increased armor protection demanded increased power of individual shots; (2) elimination of the difference in range of different calibers facilitated observation of fire, and so increased its accuracy; and (3) an increased speed having enabled the battleship to choose its battle range, it was desired to increase the previously limited effective range.

The intermediate caliber having been omitted, there remained, besides

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*The dimensions of the 50 per cent zones of the Italian 7.5-inch, 45-caliber, and 6-inch, 40-caliber, naval guns are:

| Ranges, yds. | | 2187 | 3280 | 4374 | 5468 | 6562 | 8749 | 10936 | 13123 |
|---|---|---|---|---|---|---|---|---|---|
| Vertical, feet | 7.5-in. gun | 2.5 | 3.4 | 6.9 | 11.3 | 20.5 | 53.8 | 99.7 | 160.7 |
| | 6-in. gun | 4.75 | 8.7 | 13.9 | 21.0 | 30.2 | 61.8 | 113.5 | ...... |
| Longitudinal, yds. | 7.5-in. gun | 46.2 | 46.1 | 48.7 | 55.9 | 72.1 | 106.8 | 123.5 | 130.6 |
| | 6-in. gun | 53.4 | 54.4 | 53.9 | 53.3 | 52.4 | 59.3 | 69.9 | ...... |
| Lateral, yds. | 7.5-in. gun | 0.9 | 1.5 | 2.2 | 3.0 | 3.9 | 5.9 | 8.3 | 11.4 |
| | 6-in. gun | 0.6 | 1.3 | 2.2 | 3.2 | 4.3 | 7.0 | 10.9 | ...... |

armament, only the anti-torpedoboat guns; but this, 906, to the present has been given ever greater and greater keeping step with the contemporaneous increase of radius torpedo. Thus, from the 3-inch guns of the *Dreadnought* *arolina* there has been a general return to the 6-inch; and, y is risky, a still further increase is not improbable. anti-torpedoboat armament has been increasing to a caliber of that of the intermediate armament of ships built before nary armament has been keeping pace therewith—mainly in rolong the accuracy life. In order to increase the efficiency of gun, it was necessary to increase its length; and, in order not to ssure too high, it was necessary to enlarge the powder chamber lower powder. The ratio of the cubical contents of the bore, the chamber, to the contents of the chamber, which was, for 8 and 4.9, respectively, in the cases of the Italian, 10-inch, 40-cali- 8-inch, 45-caliber guns, became 2.6 and 2.8, respectively, in the -inch, 46-caliber, and 12-inch, 50-caliber guns. As a result, the kilogram of powder was much less; and, in order to obtain a de- tial energy, it was necessary to use a considerably larger propelling which developed a higher temperature in the gun. This higher ature increased the inconvenience experienced from rapid erosion; for ds just beyond the origin of the rifling being worn after the first shots, rojectile was seated much further to the front, which changed the ty of loading and therefore the law of combustion of the powder. So n the value of the explosive was diminished. It is not an exaggeration ate that, in the type of gun in question, the velocity is reduced sensibly n shot to shot* and that the piece, in an extremely short time, is in a y bad condition.

In order to remedy that difficulty, which was aggravated when increased rength of ships demanded greater power of guns, the 12-inch gun was bandoned, and the 13.5-inch, the 14-inch, and finally the 15-inch adopted. The 50-caliber length was reduced to 45, and there is a tendency to reduce still further to 40. At the same time, the muzzle velocity was reduced, because of the increased penetration resulting from increase in the weight of the projectile and from improvement in its ballistic qualities.† These changes in the major armament are attributable to requirements of construction, so the increase in power is not in proportion to the increase in caliber.

To sum up, the super-Dreadnought is characterized, as regards offensive power, by a primary armament of major caliber guns (eight to twelve pieces), and by an anti-torpedoboat armament of sixteen or more guns, which are at present of six-inch caliber, and will probably very soon be of larger caliber. The increase in caliber of the primary armament is to keep pace

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*For the first shots the loss of velocity from one shot to the next is as much as five feet per second, but it is not so great for shots fired subsequently, as is seen from the following example:

| No. of shots with battering charge | No. of shots with reduced charge | Muzzle velocity f.s. |
|---|---|---|
| 8 | 9 | 2837 |
| 22 | 18 | 2804 |
| 36 | 34 | 2761 |
| 65 | 71 | 2742 |
| 77 | 72 | 2725 |

†The coefficient of form was reduced to about .6 by the introduction of the ballistic cap.

with the thicker armor employed, the middle belt and turret armor usually exceeding twelve inches. The speed has been carried to twenty-five knots, and the tonnage has necessarily been greatly increased. Horizontal protection, though only approximately indicated in technical publications, has, apparently, not been much increased.

### Efficiency of Ships against Coast Batteries

From what precedes, it is observed that the latest battleships are reverting, in so far as concerns the proportion between the different means of offense, to the type in use prior to 1906; but that, in other respects, there are great differences, the offensive power being doubled and the displacement almost doubled. This corroborates the observation made in the beginning of this study, that the *Dreadnought* marks a period apart from the normal cycle of evolution of the battleship—a period that is drawing to a close. However, for many years to come, ships with the characteristics of the Dreadnoughts will form part of fleets to attack coast defenses.

The development, in the Dreadnoughts, of the major caliber armament and heavy belt armor has changed the ideas concerning the relative values of the various forms of offensive action against coast batteries which had originated in a consideration of the qualities of the earlier type of ships, these ships lacking a caliber adapted to the battering of an armored fort. Thus, at the time of the maximum development of fire, as in the case of a run-by, the attack has, as compared with the coast defenses, a greater superiority of fire than has been the case since the period of sailing vessels. Indeed, if we consider only two divisions of three battleships each, they represent at least sixty shots per minute from major caliber guns; and it would be Utopian to expect of the defense a fire effect comparable to that, even though the greater accuracy of fire from land be admitted. To attain it would involve an expenditure that is wholly out of the question.*

This superiority of naval fire is, however, wholly available (and therefore the shore defenses in condition of inferiority) only in engagements at short range, when the projectile can match the armor employed by the defense, and when great accuracy of fire neutralizes the advantage of smallness of target on the part of the defense. With increased range, the fire superiority of ships rapidly decreases, for the following reasons: (1) the target grows smaller; (2) the protection afforded by the superior armor of the defense, which is unlimited by weight, is increased; (3) the batteries present (or need present) no unprotected parts, nor parts only partly protected; (4) with diminished visibility the shore defenses obtain an advantage by reason of the more effective means of range-finding possible on land; and, finally, (5) the shore defenses' system of fire control and communication is not so complicated nor so easily damaged as that aboard ship.

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*One Italian 12-inch gun emplaced and provided with ammunition for one hundred shots would cost, approximately:

| | |
|---|---|
| Gun | $ 60,000 |
| Armored carriage | 120,000 |
| Front cover | 14,000 |
| Cement and labor | 46,000 |
| 100 filled projectiles | 24,000 |
| 100 powder charges | 24,000 |
| Generators | 12,000 |
| Transportation, machinery for mounting, etc | 28,000 |
| Mounting | 12,000 |
| | $340,000 |

From the foregoing considerations relative to the merits of large calibers, and because of the lack of an intermediate armament, we may conclude: (1) that Dreadnoughts of the first type, in which the anti-torpedoboat armament is of small caliber, will avoid combat with unarmored batteries, for the reasons already set forth relative to the employment of large calibers in such operations; (2) that, for the same reasons, they will avoid bombardment, except for special reasons of morale; and (3) that, in operations of which the purpose is to destroy the batteries and attain an immediate result, ranges will be diminished as rapidly as possible—at least in so far as the fixed obstacles will permit. This method of attack is of the greater advantage to the ships, when mortar fire is taken into consideration.

The so-called super-Dreadnoughts with a comparatively strong anti-torpedoboat armament of 6-inch guns, are better adapted for an attack on open batteries. In fact, the shell of this caliber has sufficient energy to perforate shields of small and medium thickness, and is capable of destroying reasonable thicknesses of concrete parapets. They are, however, lacking in sufficient explosive force to accomplish much destruction after explosion.

From these characteristics, it is evident also that against batteries of the intermediate armament (which usually should be on pedestal mounts and provided with shields, in order to keep to the fullest extent the ease of handling that is necessary for their employment, which is usually sudden and of great rapidity) super-Dreadnoughts have a very effective arm, the 6-inch, both in caliber and in number.

As regards protection, since the side armor is constantly increasing in thickness, it follows that it must be regarded as exceptional for the major caliber gun batteries of the defense, which, unlike those of the ships, have not the choice of the range nor of the most favorable angle of presentation, to prove superior to the ships at long and medium ranges; while on the other hand, the horizontal protection of ships having remained practically unchanged and the area presented as target having been enlarged with the increase in displacement, the conditions for high-angle-fire batteries are much better than formerly.

Ships of the type built before 1906 are, because of their armament, peculiarly adapted to the attack of unprotected batteries, and, under especially favorable circumstances, can bombard from long range.

Summing up: ships built prior to 1906 appear well adapted for attacking unprotected or only partly protected works, and for bombarding; Dreadnoughts for attacks of only short duration; while the super-Dreadnoughts combine the advantages of the Dreadnoughts with those of the type that preceded.

### Characteristic Uses of the Various Types of Guns

When it is a question of replying to ships in a short and furious action, such as a run-by; of repelling torpedoboat attacks on ships under the protection of the forts; of speedily sinking vessels intended to obstruct, before they can be got into position; or when it is a question of a night attack, it is natural to employ pieces that are easy to operate and which have a flat trajectory, an extensive danger space, and great accuracy—that is to say direct fire guns. The caliber selected will, of course, depend upon the armor protection of the target to be attacked: to stop ships of the line, the most powerful guns will be used; while to repel torpedoboats or small unarmored craft, guns of smaller caliber but greater rapidity of fire will suffice.

On the other hand, when conditions are such as to cause an attack of the kinds enumerated above not to be feared, as also when, in connection with a defensive system of the type mentioned, it is desired to prolong the artillery duel and prevent an early destruction of the gun batteries by the ships' fire, the howitzer or mortar is preeminently the piece for the purpose. The mortar's effectiveness is almost independent of the range; indeed, it increases with the range, while the gun's effectiveness falls off rapidly at the longer ranges. Moreover, mortars are much cheaper, not only in themselves, but also in their emplacements; and they become obsolete much less rapidly, their effectiveness being unaffected by the continuous development of side-armor. These last two considerations are of especial importance, in view of the frequent changes necessitated in coast defense armament by the increase of naval calibers. The objections to the howitzer or mortar—long time of flight, inaccuracy, and short range—will be discussed later, when treating of this piece in particular.

Mortars also may be of various calibers, according to the work for which intended: those designed to support and protect gun batteries must have sufficient power to reach the vitals of ships, so that it will be impossible for ships to remain in the water area covered by their fire—though such absolute control is not demanded in all cases, since ships can be prevented from entering a water area from which bombardment would be possible by a convergence of fire sufficient to silence the ships' fire. In such cases it is possible to use pieces of not the latest types, even though they are of inferior power.*

The major caliber batteries should be so protected that they shall sustain the smallest possible damage from fire delivered in preparation for an attack; to which end it is a good measure, when the topography permits, to retire them to inconspicuous positions, provided their area of fire be not thereby too greatly diminished. In all cases, the armor protection must be so strong as to counterbalance, in the decisive action, the numerical inferiority of the guns of the shore defenses as compared with those of the fleet. To augment the power of the batteries, much can be done by a judicious location of obstructions, which are a necessary supplement to the defense of a channel. Since it is the object of the ships to approach the batteries close enough to overwhelm them by volume of fire, the advantage of retiring the batteries so far in rear of the outer line of obstructions as permitted by considerations of range and topography is obvious. Accordingly, since obstructions are of value only when protected, if the topography does not permit the protecting batteries to be placed close enough for the calibers ordinarily used, it will be necessary, rather than bring the line of obstructions in too close to the main batteries, to increase the caliber of the protecting batteries.

Mortars are amply protected by being emplaced for indirect fire.

## THE GUNS OF THE MAJOR ARMAMENT

The guns of the major armament must be capable of threatening the life of the ships; so the qualities demanded of them are the same as those possessed by corresponding guns aboard ship. There is this difference, however, between the conditions of employment of the guns ashore and those afloat: while the guns aboard ship can, by reason of the ship's mobility, hold the land target a long time under fire, and then approach to reap victory, for the shore guns the approach is wholly impossible, and the retention of the ship under fire practicable only so long as the fixed obstructions remain intact. If the obstructions fail, then the ships are so short a time under fire from the shore batteries, that, for the latter, decisive results cannot be hoped, even if their caliber be increased to the limit now practicable.* Therefore, in order not to be at a disadvantage in battle, it is necessary to use shore guns of the largest caliber found afloat; or, since the matter of weight is not of the same importance ashore as it is afloat, guns of a caliber superior to the largest afloat.

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*An extreme case to be considered would be that in which it would be necessary to make defense beyond the range of mortars (defense against bonbardment). We shall see in our study of the mortar that this case is quite exceptional. When it must be provided for, it will be essential to make use of a gun of such caliber that it will combine at the greatest ranges desired a not too great dispersion and a certain explosive force of projectile. For this purpose, guns of not the latest type should suffice.

What is of especial importance in the shore gun is that its ballistic qualities shall not fall off rapidly with continued firing; for, unlike naval artillery, which must correct an initial error in range-finding by bringing successive salvos nearer the target, coast artillery is in a position to begin its action with ranges accurately determined, especially at effective perforating ranges. But the coast artillery has to correct for lack of coordination between range-finder and gun; so it is obvious that, if its muzzle velocity falls off rapidly as a result of successive shots, the advantages of an exact determination of the range is lost, since the gun no longer attains the ranges indicated for certain conditions in the tables of fire.

Increase of caliber, with decrease of muzzle velocity and shortening of length of bore, tends to reduce loss of ballistic efficiency in prolonged firing; so it is to the advantage of the coast artillery to anticipate or to exaggerate advance along these lines, even though such advance does carry with it increased weight of gun and ammunition. A relatively short bore, a large caliber, a not too high muzzle velocity, a small powder chamber, and a quick grained powder should be the characteristics of the new type of artillery. Following along such lines, naval artillery has already arrived at a 15-inch caliber; so that should be the minimum for coast artillery. But the superior limit for coast artillery is not so easily determined, for the question of weight is not a consideration in coast artillery installation, nor, the weight of the 15-inch projectile being already 2000 lbs., does the question of ease in handling enter.

For purposes of comparison, the characteristics of three guns are here presented. Since, however, to enter into a technical justification of the data offered would take us beyond our limits, we restrict ourselves to a mere presentation of the figures:

| | 15-inch Gun | 15.75-inch Gun | 16.5-inch Gun |
|---|---|---|---|
| Weight of projectile, lbs. | 1951 | 2205 | 2535 |
| Weight of charge, lbs. | 320 | 375 | 432 |
| Volume of charge, cu. ft. | 8.8 | 10.02 | 11.8 |
| Muzzle energy, ft. tons | 71038 | 82660 | 95569 |
| Muzzle velocity, f.s. | 2300 | 2300 | 2300 |
| Energy of 1 lb. of powder in ft. tons | 484 | 484 | 484 |
| Length, calibers | 40 | 40 | 40 |

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*A ship steaming at twenty knots covers 5500 yards in approximately eight minutes.

The Schneider 15-inch gun, described in the pamphlet *Note sull' aumento dei calibri* recently issued by the manufacturers, agrees, so far as the characteristics considered in the above table are concerned, with the figures there given, except as to weight of charge, which is 360 lbs. instead of 320. The chief difference, which promises a longer accuracy life, is found in the allowable maximum pressure, which, in the case of the Schneider gun, is placed at 2800 atmospheres, instead of at 3000, as in the case of the Italian gun.*

This increase in pressure, at the same time that it is not disadvantageous and does permit a greater energy per pound of powder, also makes possible a quicker powder, with consequent increased regularity of muzzle velocity. The gun, however, must be somewhat heavier, since no sacrifice of the generous factor of safety usual in gun construction can be permitted; but this increased weight of gun, which is of little moment in coast armament, in any event, is compensated for, in large part, by a consequent reduction in weight of carriage.

Passing now from the consideration of interior ballistics to a consideration of the other ballistic questions involved, we find that, by the introduction of a wind shield, the shape of the projectile can be so changed as to reduce the coefficient of form to about 0.6; which, in combination with a comparatively low muzzle velocity and a high sectional density of projectile, delivers at the target a large percentage of the muzzle energy. And, though this remaining energy is not in a form best available for perforation, since it is known that the problem of perforation is most economically solved by the employment of a relatively small caliber and a high velocity of impact, yet perforation of armor is not the problem—it is only a part of it: after perforation the projectile must be capable of developing sufficient explosive force to cause extensive damage to the ship. But, with a caliber equal to, or perhaps less than the thickness of armor to be attacked, the projectile must possess to an exaggerated degree the qualities required for perforation—maximum thickness of wall and minimum weight of bursting charge. So, while the 12-inch projectile could not carry more than 13 to 14.5 lbs. of trinitrotoluol, for a larger caliber the bursting charge could be increased, not only in proportion to the increase in caliber, but in advance thereof, since it would not be necessary to develop the maximum perforating qualities of the projectile, it being of a caliber superior to the thickness of armor to be attacked. Thus is attained a projectile that is a compromise between the armor-piercing and the semi-armor-piercing; and, for this caliber, at any rate, a single projectile is realized.

### INTERMEDIATE AND MINOR CALIBERS

In the case of the major caliber gun, the ballistic problem to be solved was, by its very nature, capable of exact statement, and therefore its solution, if not strictly deducible from the premises, was capable of satisfactory approximation. For the minor caliber guns, however, conditions vary so

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*An interesting comparison of the type of gun proposed with the 12-inch, 50-caliber gun, is given below.

| | Proposed gun | 12-inch, 50-caliber gun |
|---|---|---|
| Volume of the powder chamber referred to the caliber [actual length in calibers?] | 4.5 | 11.2 |
| [Reduced length of powder chamber in calibers | 6.3(?) | 13.9(?)] |
| Ratio of the volume of the total bore, except chamber, to the volume of the chamber (expansions) | 5.6 | 2.8 |
| Energy of 1 lb. of powder in ft. tons | 484 | 345 |

widely from place to place, or even from battery to battery, that the selection of a single caliber is outside the realm of the possible.

We have, however, a key to the situation in the analogy existing between this armament and the anti-torpedoboat armament of the Dreadnoughts, the two having a common object: both ashore and afloat the smaller armament is employed against targets of little or no vertical protection, the reason for its increase in caliber from three to six inches aboard ship being found almost wholly in the question of the range at which it is proposed normally to employ the armament. Analogously, it may be concluded that for the minor coast battery the gun must be chosen within the limits just mentioned, or beyond them, in view of the prediction of an increase of caliber made in speaking of naval artillery. The choice of a particular caliber will be dictated by purely local conditions, small calibers being ordinarily used where the hydrography compels the enemy to pass at close range, or where the batteries are close to the obstructions which they defend, and proportionately larger calibers being used as the conditions become less favorable for the defense.

If the guns are of small caliber, and consequently of great rapidity of fire, the system of fire control must be simple and necessarily based on observation of fire, since the practicable range finding will be reduced to obtaining the range for the first shot. Hence, it is of little importance whether the velocity decreases from shot to shot, agreement of range-finder ranges and sight-bar ranges not being required in continuing the fire. Indeed, it is desirable to have the greatest possible flatness of trajectory, in order to increase the danger space, and this calls for the highest muzzle velocity.

For those batteries, however, that demand a caliber greater than six inches, the normal battle range, the slower service, and the importance of the individual shot make it advisable to make greater use of range-finding instruments, which leads to a sort of fire-control system. Then we meet again the considerations developed when treating of the major-caliber, and conclude that somewhat moderate muzzle energies are to be preferred.

### THE MORTAR OR HOWITZER

Unlike other types of cannon, howitzers and mortars enter into systems of land armament only; and they have the advantage of attacking ships where armor protection is deficient. It has already been remarked that the battleship is designed for naval combat, that is, for the contest for the control of the sea; and it may now be pointed out that, in determining upon the details of ship construction, the demands of volume of fire, of armor protection, of speed, and of extended radius of action, are so insistent as to preclude, in general, taking into consideration a possible attack on a coast; hence, the explanation of the fact that, for some years, no advance has been made in the horizontal protection afforded battleships.

Nor, if it were desired to advance in that direction, would advance be easy. The horizontal area of a ship is more than double the vertical area; therefore, since the deck must cover everything, an increase in the thickness of the deck armor would entail a very considerable increase in the proportion to the total of the displacement allowed for armor protection in ship design. Accordingly, an increase in deck armor could be only extremely limited. Moreover, the deck plates being thin, as compared with the caliber and weight of the attacking projectile, which falls upon

[illegible]

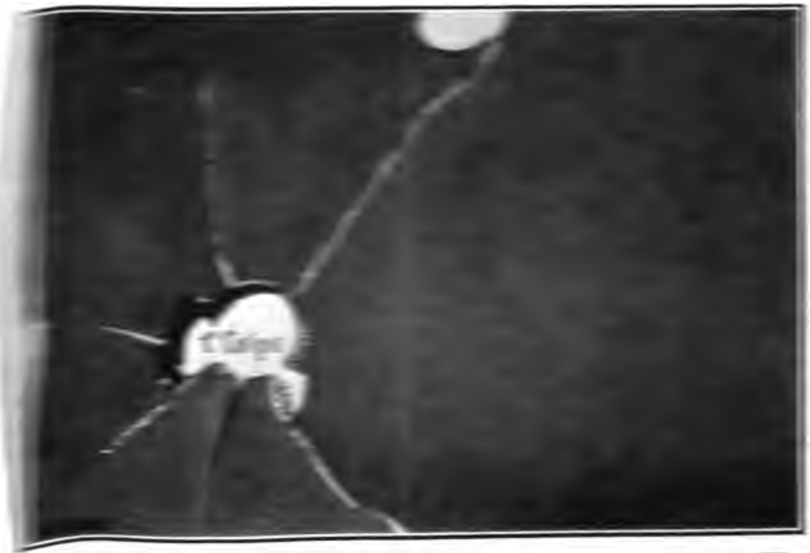

Fig. 1. 1st Shot

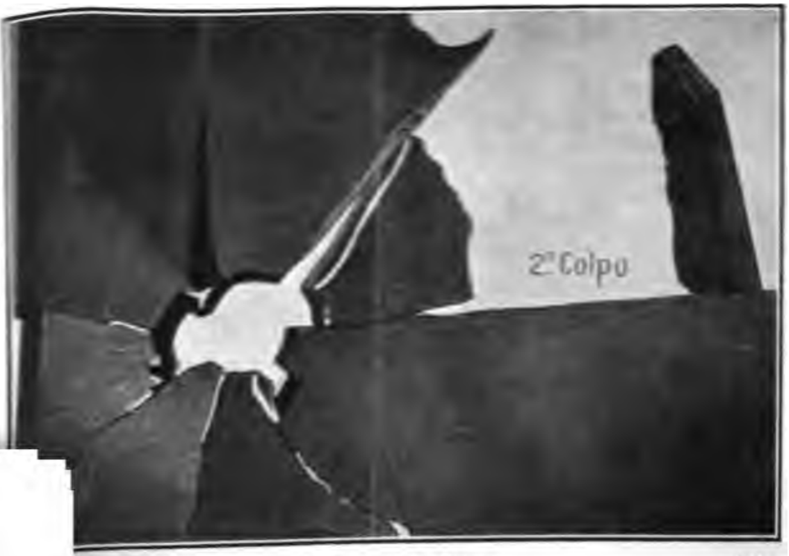

Fig. 2. 2nd Shot

1044

This being the case, not only now but for some time to come, it is evident that the mortar, as compared with the gun, will retain its superiority without an increase in caliber.

The disadvantages of the mortar are found in its long time of flight, its inaccuracy, and its short range.

The long time of flight makes necessary a prediction of the position of the target at the end of a comparatively long interval, under the assumption that the target will keep both its course and its speed; whereas, a ship can change at will either its course or its speed. However, while this criticism is of importance theoretically, yet practically it happens that, if the ship intends to return the fire, it must maintain a certain regularity of course. Here is the gist of the question: if the fleet desires merely to pass through the defended area with a minimum damage, a defense with mortars only will not be very effective (it has already been pointed out that this is exactly the rôle of the gun); but if the object of the attack is to be attained by fire, whether bombardmemt or silencing of the works, it is obvious that a course sufficiently regular for the purpose reduces the disadvantages considered to very minor importance.

Inaccuracy of fire is to be considered, not absolutely, but relatively to the area of the target effectively attacked by individual shots. Designating by 1 the area of the vertical target presented by a ship, the area of the available* horizontal target presented by the same ship is as shown in the following table. (See also Figs. 3 to 8, pages 360 and 361.)

Target Presented

| Angle of fall | Ships of "King George V" class (English) | Ships of "Kaiser" class (German) |
|---|---|---|
| 4° (12-inch gun at 6562 yds.) | 1 | 1 |
| 35° (mean for curved fire, the minimum being 20°) | 2.5 | 2.6 |
| 60° (mean for high angle fire) | 2.4 | 2.5 |

The relative dispersions of gun and mortar (or howitzer) at the usual battle ranges are shown in the following table.

Relative Dispersions

| Piece | 5000 yds. | 7500 yds. | 10,000 yds. |
|---|---|---|---|
| 7.5-inch gun (vertical dispersion) | 1 | 1 | 1 |
| 11.02-inch howitzer (mean longitudinal dispersion) | 17.3 | 3.9 | 2 |
| 11.02-inch mortar (mean longitudinal dispersion) | 11.0 | 3.8 | ... |

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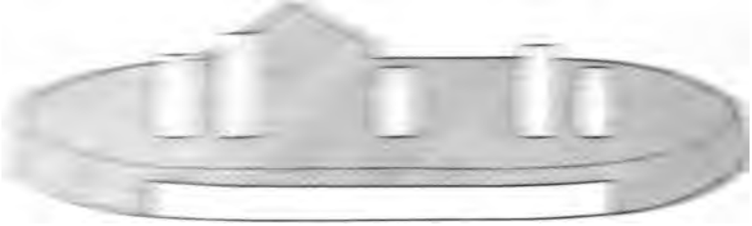
*_Available_, that is, capable of being perforated by the projectile of the 12-inch gun or mortar.

[illegible]

[illegible]



[illegible]

[illegible]

---

[illegible]

[illegible]

| [illegible] | [illegible] yds. | [illegible] yds. | [illegible] yds. |
|---|---|---|---|
| Gun | [illegible] | [illegible] | 1 |
| Howitzer | 1 [illegible] | 1 [illegible] | 1 [illegible] |
| Mortar | 1 [illegible] | 0.69 | ... |

it appears that the howitzer or mortar at short ranges is de- [illegible] to the gun; but that at long ranges, when the vulnerable [illegible] target is considered, the howitzer is equal to or superior to the

range is not inherent in the howitzer or mortar, as appears from 12-inch, 17-caliber howitzer, which has a range of 15,310 yards; naturally, attaining that long range involves rather complex tech-

### TARGET PRESENTED BY A SHIP OF THE "KAISER" CLASS

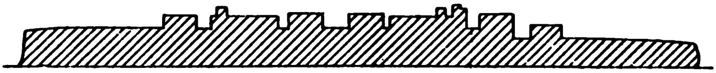


FIG. 6.
1648
To a 12-inch gun (angle of fall, 3°45′)

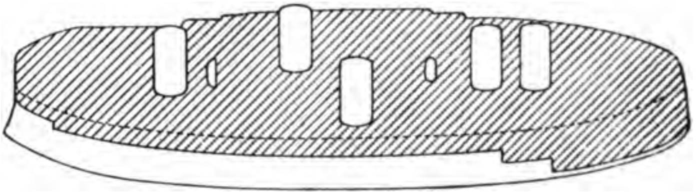


FIG. 7.
1649
To an 11.02-inch howitzer (angle of fall, 35°)

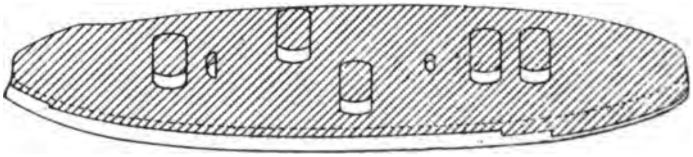


FIG. 8.
1650
To an 11.02-inch mortar (angle of fall, 60°)

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nical problems, which are, however, far from being incapable of solution, especially when it is considered that, in seacoast installation, neither length of bore nor weight of piece greatly affect convenience of service or rapidity of fire; and that it is not, therefore, a question of ballistic efficiency per hundredweight of material installed.

High velocities, and consequently comparatively strong charges, being demanded at the long ranges, at the short ranges, for which must be used very small charges in a comparatively large chamber, there may occur pressures of insufficient force to arm the fuses, and there may be experienced difficulty and irregularity in the burning of the charge itself. One way to remedy that trouble is to make use of a relatively small chamber, increasing the density of loading in the case of the larger charges well up towards the maximum allowable and giving rise to high pressures, in order to be able uniformly to employ rather quick, and therefore more regular, powder —notably quick powder for the smaller charges. A second and much more radical way is to attempt to make the cubical contents of the powder chamber variable by means similar to, but less crude than, the means employed for the same purpose at proving grounds.

The seacoast howitzer or mortar should, therefore, have an initial velocity of not less than 1640 f.s., which is higher than that of the old Italian 9.5-inch and 12.6-inch guns. But it is not necessary that this velocity be used with a heavy projectile, since its only object is to make practicable ranges greater than 15,000 yds. for the purpose of preventing ships' firing at such ranges, while remaining undisturbed themselves. And, in as much as there cannot be expected from the ships' fire at such ranges results of much importance, the risk of their sustaining damage themselves, even though it be only to parts above water, will tend to prevent the ships' delivering long range fire.

It is sufficient if the heavy projectile* can be used at ranges as great as those from which naval fire can be effectively directed against small targets. The first requirement (range with a light projectile), therefore, being met, the second is, by its very nature, satisfactorily met.

Of the light projectile a greater power of perforation than that needed for perforating ordinary decks, is not demanded, since to require of it perforation of the protective deck also would necessitate a too great sacrifice of bursting energy. Assuming, therefore, mean obliquity of impact for the projectile upon the deck, in consequence of the values of the angle of fall, it will be sufficient to demand that the projectile be able to perforate, at normal impact, 1.54 inches of nickel-chrome steel. For a projectile, of the ordinary caliber of coast howitzers or mortars, which satisfies the above conditions, we have the equation,

$$\frac{W}{d^3} = 0.45$$

in which,

$W$ = the weight of the projectile in pounds; and

$d$ = the caliber in inches.

The bursting charge can be as much as twelve per cent of the weight of the projectile, which has therefore all the characteristics of the modern torpedo shell.

An armor piercing projectile should be given the greatest weight compatible with its caliber, in order that it may attain the greatest possible energy of impact for the range, or, rather, for the curvature of trajectory. The armor piercing quality that is required, demanding a not excessive thickness of wall, makes possible a weight not above that for which

$$\frac{W}{d^3} = 0.576;$$

so the bursting charge can equal, as has been said, five per cent of the weight of the projectile; which gives us a projectile of sufficient bursting energy to insure results after the deck has been perforated.

The caliber of the piece in which to use this ammunition, cannot be directly determined; for, while at the shorter ranges we should not effect perforation even though we went to unacceptable calibers, on the other hand, at the longer ranges, we attain perforation with calibers smaller than those generally approved. Therefore it will be convenient to start with the projectile; and since the ship's horizontal protection, allowing for the angle of fall of the projectile, is always well inside six inches, the 12-inch caliber may be regarded as ample.

As with the gun, it is desirable here also to obtain a solution which will give a factor of safety in armor-piercing quality. If ten per cent is adopted, we have the following two solutions:

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*This projectile has walls somewhat thinner than those of the gun projectile known as semi-armor-piercing, and can carry a five per cent bursting charge, at the same time that it is adapted for attacking plates of thickness equal to half the caliber.

| Maximum I.V. f.s. | | 12-inch caliber | 13.4-inch caliber |
|---|---|---|---|
| 1443 | Weight of heavy projectile, lbs..... | 1003 | 1389 |
| | Weight of bursting charge, lbs..... | 48.5 | 66 |
| 1640 | Weight of light projectile, lbs...... | 782 | 1085 |
| | Weight of bursting charge, lbs...... | 95 | 130 |

For cases in which the factor of safety in range and armor-piercing quality here considered is not necessary (as for instance, when it is a question of defending places against which there would be no reason for an enemy to attempt a decisive action), a lighter piece also is useful. So the Italian 11.02-inch mortar, if supplied with suitably small ammunition, could be reduced to a 9.5-inch caliber, with very little expense, by means of an adapter lining. The following would be the characteristics of such a piece:

| | |
|---|---|
| Caliber, inches | 9.5 |
| Heavy projectile, | |
| Weight, lbs | 478 |
| Bursting charge, lbs | 24.25 |
| Maximum I. V., f.s | 1344 |
| Light projectile, | |
| Weight, lbs | 377 |
| Bursting charge, lbs | 46.29 |
| Maximum I. V., f.s | 1640 |

### Proportion of the Various Types of Arms in the Defense

From what has been set forth, the artillery defense for the coast should include:

High power guns of caliber not less than 15 inches;

Smaller guns of caliber varying according to the object to be attained;

High power, long range howitzers or mortars of caliber not less than 12 inches;

Mortars of comparatively low power.

The conclusions at which we have already arrived are, indeed, not absolute;* but when, passing from an examination of each type of piece, we wish to proceed to establish a criterion with which to determine the proportion between the various pieces, it is no longer possible even to treat the question in a general way, making a mental abstraction of the fortified place, when considered from the point of view of its peculiar strategic character, of the conformation of the coast, of the influence of circumstances, etc. However, for obvious reasons of secrecy, it is impossible to support these statements with an examination of defensive systems, such as those of the Italian fortified places;* so we are limited to a summary of the conclusions which flow from such an examination.

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*Thus there are in some places land-locked harbors, to cover which there is no need of extended range. In such cases, a mortar of a smaller maximum initial velocity, having a smaller powder chamber, will give greater precision of fire and a minimum range more suitable for the defense.

1. The proportion of guns and mortars, and the choice of caliber for the mortars and the smaller guns, are governed by no fixed rule, being dependent upon the topography of the place, or of that portion of it for the defense of which the battery is intended. Moreover, in fortified places having similar objects, there may be a great difference in the types and proportions of the pieces best suited for defense.

2. In fortified places of strategic importance, guns, on account of their simpler service, should predominate. In places of second rate importance, the defense may be entrusted, as a rule, almost wholly to howitzers or mortars, and these, too, of not very great caliber. In general, the very costly batteries of large guns are restricted to the defense of channels, the more economical mortar being assigned all those tasks in which is required only neutralization of the ships' fire, whether it be bombardment or an attempt to silence the works.

3. The big gun batteries, when not especially numerous, should be kept out of long range action, in order to preserve all of their offensive power for the decisive moment of the action; and the same thing applies to the smaller gun batteries; though these two requirements cannot always be fulfilled.

### SYSTEMS OF FIRE DIRECTION FOR THE DIFFERENT TYPES OF PIECE

The gun, as has been said, must be characterized by extreme simplicity of fire direction, both because upon it will devolve the duty of sustaining the action in its most rapid phase, and because upon it, at least upon the major caliber, will be directed all the fire of the attack in the final struggle, when the defense, including, perhaps, the personnel manning such guns, will have been worn out in the previous phases of action.

In order to secure such simplicity of direction, we must be able to count upon a system of range-finding that will give the range to within a negligible error as compared with the error of the piece;† and that may be counted on at the normal ranges for guns such as those already determined upon.

Assuming that, let us consider a ship maneuvering in the field of fire of a gun battery: the law of its motion can, with sufficient approximation, be considered such that every point of the ship's axis will pass where the bow passes; so it will suffice, within certain limits for the relation between the speed of the ship and the time of flight of the projectile, to aim at the bow, using data applicable to the present range of the bow, since the shot will strike the ship at a point more or less aft.‡

Assuming the limiting case of a battleship only 410 feet between perpendiculars and having a speed of twenty-five knots, we conclude that major caliber guns of the type we have proposed could, without need of prediction, be fired at ranges as great as 5500 to 6500 yards, corresponding to a time of flight of about 9.7 seconds. Of course, as the limit mentioned is approached, the shots will begin to strike the ship near the stern, a section which is not of the greatest importance as a target; so, in practice, the limiting range should be reduced somewhat.

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*The examination was made in the original study, but was omitted in publication.

†This condition is practically satisfied when the probable range-finding error does not exceed half the probable error of the gun; for then the total probable error is to the probable error of the gun as 1 is to 0.9.

‡This system has already been presented by Colonel Righi in an article that appeared in the *Rivista d'Artiglieria e Genio.*

Assuming what has been stated relative to major caliber batteries, it remains to be shown that, in the general case, this method of firing satisfactorily accomplishes its purpose. The range-finder continually furnishes the range from the guns to the target; the guns, after being loaded, are given a suitable elevation, and, as soon as that elevation is indicated by the range-finder, are fired. The method has also the advantage of rendering the pieces independent of one another, when that is desirable, and therefore of making possible a maximum rapidity of fire. There being no danger of confusion in the identification of shots that fall about the target, because of the small number of batteries which the defense generally has, there is no necessity for firing by battery salvo.

Opposed to this tempting simplicity of the method, however, is the already mentioned inconvenience that results from its use in the extreme case (namely, firing too far aft), an inconvenience which is felt the more as the course of the target coincides more nearly with the line of fire. Moreover, the limiting range of its use is rather small; and it is well not to introduce a lack of uniformity in methods of firing at long, medium, and short range; so it is desirable that the simpler method, applicable to medium and short range, shall be only a particular case of the normal method, some calculations being omitted. So the simplified system of fire direction should be derived from the system already in use for both range and direction, study being made to determine what operations may be omitted for ranges under 6500 or 7500 yards.

In the solution of the deflection problem, it is not possible to attain greater simplicity than is now had in the solution in current use; but in the range problem simplification is possible because of the extent of the danger space for a target, such as the modern battleship, which is of a height not less than twenty-three feet.

Let us assume an approaching target—a ship of the line firing upon our battery. The angle which the course of the ship makes with the normal to the axis of the battery, we shall represent by $\theta$, and the ship's speed by $S$, in yards per second. Then, assuming the range readings to be always taken on the bow, in the time of flight $T$, the ship travels toward the battery a distance represented by

$$ST \sin \theta;$$

and, at the end of the time of flight, the stern will be in a position relative to the original position of the bow, both positions being projected on the normal to the battery, represented by

$$(ST-L) \sin \theta,$$

$L$ being the length of the ship.

Up to a range of about 8700 yards* the value of that expression never

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*This limiting range can be determined with the aid of the range table. For example, for the 12-inch, 40-caliber gun of the Italian navy, the time of flight for 9842 yards is 17 seconds, and the danger space for a target 23 feet high is 38 yards; therefore, still considering a ship of 410-ft. length, and 25 knots, or 12.5 yds. per second, the condition that $(ST-L) \sin \theta =$ danger space gives the equation,

$$\left[(12.5 \times 17) - \frac{410}{3}\right] \sin \theta = 35$$

which is satisfied for $\theta = 30°$.

At a range of 8749 yds., for which $T$ is 14.5 seconds and the danger space is 48 yards, the equation is satisfied for $\theta = 90°$.

The major caliber gun which we have considered, very nearly meets the above conditions.

equals the danger space of the battery; therefore it is possible to fire with correction for deflection only, to the allowance for drift being added allowance for the lateral component of the travel of the target. This system of fire direction, even though hampered by the necessity for calculating the deflection, is extremely simple; especially since the calculation does not demand great accuracy and need not be made for each shot. Moreover, there is gained the advantage of directing the fire upon the section of the ship's side which offers the best chance for effective attack.

This simplified system of fire direction matches the more elementary system described, and therefore may be substituted therefor habitually at short and medium range. It is to be noted that the range to be indicated to the guns differs according to whether the target is approaching or going out—if approaching, the actual range; if going out, the actual range plus the danger space. However, the resultant complication is more apparent than real, since it will be met by having an indicator with two graduations—one for an approaching target, and another for a receding target.

The system of fire direction for major caliber guns should, then, be the one now in use, for ranges greater than 8750 yards; and, for ranges less than 8750 yards, the same system with correction for range omitted. When the correction for range is omitted, fire by piece, if desired, may be used instead of fire by battery.

Guns of the intermediate and minor calibers are intended to fire at shorter ranges than those mentioned; but, on the other hand, their targets are generally shorter and more speedy than are ships of the line. Therefore, those of intermediate caliber (to which we attribute an initial velocity of 2300 f.s.) make use of the same system of fire direction as that described for the major caliber; while those of minor caliber (which have high initial velocities) if equipped with range-finders, fire in a similar manner, omitting range correction for travel, and, if unequipped with range-finders, find the range by observation of fire.*

Mortar fire, because of the long time of flight, may be of very limited effect, on account of inaccuracy, when it is attempted to hit a ship that maneuvers with the specific purpose of avoiding being hit; and that is the strongest argument which opponents of the mortar can cite in evidence of its not being suitable for coast defense. There is, indeed, no denying that some of the influences beyond the control of the battery commander which affect coast artillery fire (such as instrumental error in determining the speed of the target, maneuvering of the target, etc.), do have special significance in the case of the mortar, on account of the long time of flight; but in theoretical discussion there is an involuntary disposition to attach entirely too much importance to that disadvantage. In the first place, the case of a solitary ship's presenting itself in the battery's field of fire is exceptional; ordinarily, instead, there will be more targets, bound to one another in the tactical formations of a naval division or fleet, or, at least, with freedom of movement restricted by the mutual requirements of maneuver. In the second place, a water area is not, as a rule, commanded by a single battery; and, if two or more works are assigned the same target, the target

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*A 4.72-inch gun, of 2950 f.s. initial velocity, has times of flight as follows:

| | | | | |
|---|---|---|---|---|
| Range, yds............. | 2187 | 3280 | 4375 | 5470 |
| Time of flight, sec........ | 2.6 | 4.3 | 6.4 | 8.9 |

will experience greater difficulty in avoiding the shots. Finally, it is to be remarked that the crossing of an area, when there is any object worth while to be attained by the crossing, is opposed by obstructions which must first be removed.

Notwithstanding the inherent force of these remarks, we have already pointed out the lack of appropriateness of the mortar for the defense of passages, especially because it is not possible to count on the safety of the obstructions. Accordingly, we have restricted the use of the mortar to attacking ships which deliver their attack by fire; and, in as much as such ships must employ a maneuver that will make possible a methodical execution of fire, that is, follow a route composed of rectilinear courses at constant speed in which to deliver their salvos, the mortar will be able to fire upon those courses using the system of fire direction now in vogue. With modern batteries, capable of firing a salvo every minute, it is no longer to be expected that the ship will be able to profit by the intervals between salvos so far as to make the rectilinear courses of its track, and therefore its broadsides, coincide therewith; at any rate, it is not impossible to reduce the firing interval, either by recourse to half-battery (or pit) salvos, or by recourse to fire by piece. The means for accomplishing the purpose can be specially studied, and they present no particular difficulty; but it would exceed the limits set for the present article to treat of them with the necessary detail.

## EMPLOYMENT OF THE BATTERIES

In other branches of artillery, the word "employment" (*impiego*) has a broad significance that is related to the development of the *tactical* use of the three arms combined; but in the coast artillery branch its significance is, instead, generally one of the *technical* use of fire for the purpose of getting the maximum results, considering the object to be attained. Of course, the coast battery lacks the one quality which is needed for the introduction of initiative into the defense—mobility. The artillery defense of a harbor, considered from any point of view, is therefore wholly passive, in as much as it is incapable of extending its attack beyond the limits fixed in time of peace by the choice of position for the batteries and the selection of the characteristics of the piece with which to arm them.

Under such circumstances, to speak of coordinating the artillery action of all the works of a fortified place in the attainment of a single object, would appear somewhat rash—except, of course, in the case of batteries having a common fire area, that is, batteries grouped for defense; and then the action of the group commander is of a tactical nature only if considerations other than that of inflicting upon the several ships of the enemy the greatest damage in a given time demand a distribution of targets among the various batteries. Hence, we shall confine our investigation to a study of the action of the group commander and of the batteries, and to an enumeration of the rules to be followed in the selection of targets and the opening of fire.

A group is composed of batteries, no matter what their relative locations, that have a common area of fire, and, with certain reservations, a common object to be attained. With that as a definition, and going back to the study of the defensive system made when treating of the proportion between the various kinds of armament, we may say that groups are composed of:

(*a*) Batteries intended for the protection of the active fighting forces against naval fire from areas not otherwise covered, as also batteries designed to protect cities and commercial ports against bombardment, the division into groups being according to the possible division into sectors of the area commanded.

(*b*) Batteries for distant defense, charged with covering water areas at long range, beyond the entrances to harbors of strategic importance or to harbors of refuge, beyond narrows, etc.

(*c*) Batteries for near defense, which cross their fire in the zone immediately in front of entrances; batteries intended to protect obstructions, etc.

This division of the batteries into groups corresponds also, in a general way, to the different kinds of action on the part of the attack, and hence to the different methods of employing the batteries for counteracting or stopping those actions.

The groups of batteries described in (*a*) will seldom be called into action: the defense they afford consists normally in possessing great power, it being the exception for their power to have to be made use of. Indeed, it must be recognized that ships will avoid running the risk of serious damage in this way, when their object might fail of attainment through their indirect fire against anchorages' not having the desired effect, through the bombarded city or port's not sustaining as great damage as might be hoped for, or through the attack's not deriving the hoped for moral effect.

In our study, however, we must consider the case in which the water area is favorable for the attack. The enemy, whatever the kind of offensive action that is to be developed, will find it advantageous to appear unexpectedly in order to profit by a possible relaxation in watchfulness on the part of the defense; then it is to be expected that the fire action of the attack will begin suddenly with the greatest intensity that is compatible with the accuracy demanded by the situation; later, when the fire of the defense has attained its normal intensity and precision, probably the enemy will withdraw. But even if the action opens in a different way from this, it is certain that a methodical struggle, begun with putting the batteries out of action, is not to be supposed; because, even admitting that the batteries might be silenced, it would take a long time, on account of the coast batteries' system of indirect laying, and could entail upon the attack losses out of all proportion to the results finally attained.

These characteristics of the attack being assumed, it follows necessarily that the fire of the defense, if not always of very short duration, yet will probably not be fully enough developed for results of real importance to be attained. It does not appear advisable, therefore, to adopt methods of fire which, such as concentrating the fire of several batteries on one or on very few ships, reduce the sum total of the damage that can be inflicted in a given time, but increase the probability of putting out of action some one ship. It will be more advantageous to assign a separate target to each battery, thereby rendering easier correction from observation of fire.

The assignment of targets should be so made that the ships shall be subjected to fire under the conditions most advantageous for the batteries, as regards range, armor protection, and maneuver. The choice of the kind of fire with which to attack the ship will depend upon the range and the maneuver, as will be shown.

The remaining energy of the howitzer or mortar projectile increases with the range; while, on the other hand, with an increase of range, accuracy of fire diminishes, on account of the increase in dispersion and the decrease in accuracy of ranges. Dispersion increases rather slowly with the range; but the error in range increases as the square of the range. From these two conditions arises, for the battery, a zone of greatest efficiency, the inner boundary of which is the range at which the remaining velocity is sufficient for perforation, and the outer boundary the limit of useful employment of the range-finder assigned the work. The assignment of targets must obviously be made in such a way that each battery shall, so far as possible, be employed in that zone.

As we have seen in the discussion of ships in the first part of this article, the horizontal protection of ships of the line has remained practically unchanged, being about the same in the new types as in the old. Therefore if the maneuvering of the ship is such as to enable the battery to use high angle fire, it is better that there be selected as target the most recent, and therefore the most powerful, type of ship. If afterwards recourse must be had to direct fire, it is necessary to take into consideration the horizontal target and the proportion of unprotected freeboard which the different types of ship present; and since, in this case also, the most advantageous target will be presented by the most recent ship, we can say that, in general, other things being equal, there should be chosen as target the most modern naval unit.

The maneuver depends upon the object which the ship has in view: thus, of two groups of ships, one charged with firing on a battery for the purpose of annoying the cannoneers and so rendering their fire less deliberate and therefore less to be feared, and the other detailed to fire upon an extensive target, the first is much more bound to follow a regular course than is the second. In the selection of targets, therefore, account must be taken of the ships' fire, the selection falling upon such as are firing upon batteries.

So much for the function of the group commander.

The battery commander, in deciding upon the kind of fire, will take into account that high angle fire affords the greatest efficacy of single hit, but is a little less accurate and has much longer times of flight than direct fire, and that the advantages and disadvantages of the one as compared with the other generally balance.*

High angle fire is, however, rather indicated for use against targets that fire from a fixed point or that follow a very regular course, as well as against targets which, as a result of damage sustained in the engagement, no longer maneuver; while direct fire is indicated for other cases.

In operations directed against the entrance to a fortified port, against narrows, etc., attack upon the exterior batteries either will not be undertaken, or will extend to reducing them in succession, in order to be able afterwards to proceed energetically to the destruction of the interior defenses. The first alternative presupposes a surprise, and is practicable only when, in the early hours of the war, the batteries happen not yet to have their complete garrisons, the mine defense not yet to be put down, and the searchlights not yet to be in operation; the conditions most favorable for its execution are night and cloudy weather, if it is a question of torpedoboat attacks against the units of a fleet under protection of the defenses, or dawn or twilight, if it is a question of fire action against such units.

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*Indeed, not only have there been advocates of the one kind of fire and of the other, but even entire periods in which now the one system and now the other has been in favor; and only now, from the irreconcilable nature of the thing, has arisen a new doctrine that the battery commander should be left to make use of all the various means of attack to which his piece lends itself, it being for him to decide in each case the most advantageous kind of fire.

The second alternative is developed methodically, the work of destruction beginning from the flanks, which is sometimes possible, through lack of proper defensive measures (that is, when a water area suitable for an effective attack by the fleet, is commanded by an inadequate number of guns). When this is the case, the action can be developed at about the outer limit of mid-range, although, for the better use of naval fire, it may be preferred to have it open at relatively short range, since, with reduction of range, there is increased accuracy for the ships' guns and diminished effectiveness of howitzer or mortar fire.

For the development of the action, general rules cannot be prescribed, because, as has been remarked when discussing the proportion between the different types of armament for the defense, the conditions of the action vary with differences in the topography of the place and the arrangement of the batteries.

The battery's action should be directed much more toward the ultimate interests of the defense, than toward safeguarding its won forces; nor should it permit itself to be led, by the hope of the possible sinking of some unit, to develop the attack against that one beyond due proportion. We have already said that, from its very nature, only exceptionally can the coast artillery reap the fruit of victory, since it lacks the mobility that is necessary therefor; a rather seriously damaged ship, provided its ability to maneuver is retained, will immediately withdraw from the water area effectively covered by the defense; and it is not to be hoped that in such a short time it is possible greatly to aggravate its condition—much less to sink it.

As soon as a ship has sustained such damage as to cause it to retire, it is better to abandon it and to give attention to those which more urgently demand it. Only when the defense has established its superiority and the enemy has had to abandon its undertaking, is it well to seek a decisive victory; but the pursuit of the ships, already very much damaged by fire, will have to be sought by means of torpedoboats assigned to the defense —a phase of the defensive action which is outside our limits.

As targets, ships carrying a numerous armament of major caliber are to be preferred, because such ships are capable of more effective employment against naval forces protected by the fortifications and against gun batteries, and notwithstanding that they are less effective against the exterior works and take only a secondary part in that phase of the engagement.

Assuredly, the group commander's work at this time is very difficult: he must estimate the offensive power of each ship, taking into consideration the range to it as a target, that is, taking into consideration the effect which the fire of the batteries will have upon it; he must be on a sharp lookout to take advantage of the first sign of, and to meet with all means in his power, attempts directed against the port; he must estimate correctly the importance of the action, in order that he may decide when the fire of the batteries may be entirely taken up with the tactically negative action of obstructing the advance of the attacker, and when he may allow himself to attack more in detail.

As for the battery, here as in the previous case, the choice of the kind of fire (direct or indirect) must depend upon the maneuvering of the target.

The presence of fixed obstructions is, as we have seen, of capital importance in the defense of a harbor for the closing of a channel. It is, in fact, indispensable for keeping the ships from proceeding directly to the accomplishment of their purpose, in defiance of the batteries, which, in the absence of obstructions, would be capable of use too short a time. Against the obstructions, therefore, the attack will direct operations throughout its attempt on the fortifications; so the guarding of them must be unremitting and most careful, especially when darkness or meterological conditions render it most difficult.

The batteries of major caliber guns are called into action, as a rule, at the critical moment of the defense; their employment normally begins very suddenly, and they find themselves, without other support, pitted against ships which, as we have said, have at their disposal an enormous preponderance of fire. Under these conditions, the part taken by the group commander cannot be so important as in the other cases considered; the action is almost incapable of being ordered according to previously arranged tactical form, and tends to develop into an individual contest between ship and battery; it will not be more than a direct conflict between two forces, one provided with great offensive power, but comparatively poorly protected, and the other with great resisting power, but not so liberally supplied with arms.
—*Mitteilungen über Gegenstande des Artillerie-und Geniewesens.*

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## OPERATIONS AGAINST THE DARDANELLES

## I

### General View

### NATURE OF THE OPERATIONS

To follow in detail the nature of the operations which are being carried out by the allied fleet we must understand the nature of the defenses which have to be broken down. These are three-fold: First, the heavy, long-range, armor-piercing guns, generally mounted on high elevations; second, the batteries of rapid-fire guns emplaced nearer sea level and the shore, which protect the mine fields and prevent mine-sweeping operations; and, lastly, the mine fields themselves.

The heavy batteries of the forts at the Narrows are armed with guns of from 9.2 up to 14-inch caliber; and the first step was to reduce these guns, if possible at a distance which would place the ships outside of the range of the forts. For this work the British Admiralty designated the most powerful ship of the British navy, the *Queen Elizabeth,* which has just been commissioned. This vessel mounts eight 15-inch guns, which fire a 1925-pound, high-explosive shell with a velocity of 2500 feet per second. For the purpose of attack, the ship took station off the north coast of the Gallipoli Peninsula near the Gulf of Saros. Between her and the forts, running down the peninsula, was a ridge of hills several hundred feet in height, which of course, shut out the forts from view. The firing was what is known as indirect—that is to say, the gunners could not see the target—and the range, according to the British Admiralty report, was about 11½ miles. The fall of the shell was noted by aeroplanes and by ships at the entrance to the strait and the proper correction was sent to the *Queen Elizabeth* by wireless.

When the heavy guns had been silenced, two semi-dreadnoughts, the *Agamemnon* and the *Lord Nelson*, supported by the French battleships *Gaulois*, *Charlemagne*, *Bouvet*, and *Suffren*, engaged the forts in the Narrows at from 12,000 to 14,000 yards by direct fire; that is to say, the gunners were able to lay the gun sights directly on the forts.

Following the reduction of the heavy guns, the armored ships were sent in to closer range, where they demolished the rapid-fire batteries of 4, 4.7, and 5.9-inch guns as the case might be, which were mounted so as to cover the mine fields and prevent countermining.

For the work of clearing out the mines the British Admiralty, if we may judge from the dispatches, has sent out with the fleet several of those North Sea steam trawlers of which we have heard so much during the present war. These vessels, in pairs, drag over the course of the channel to be cleared of mines a series of heavy chains, which engage the anchorage cables of the mines and enable the latter to be drawn aside from the channel, or brought to the surface and rendered harmless by exploding them. Into the channel as thus cleared the fleet moves up, and the process of the reduction of the next fort or series of forts within range is proceeded with.

### THE DEFENSES

The following detailed description of the defenses of the Dardanelles and Constantinople, is translated from the *Handbuch fuer Heer und Flotte:* The Strait of the Dardanelles connecting the Aegean Sea with the Sea of Marmora is about 70 kilometers long, with an average width of 4 to 5 kilometers. At the western entrance the width is 4 kilometers, at the narrowest portion between Kalid-Bahr and Kale-Sultanije (Tschanak Narrows) only 1300 meters wide. The European shore is cliff-like in formation, with the exception of the mouths of small streams, and is topped by 200 to 300-meter hills. Large war vessels can easily pass through the straits, but the strong current from the Marmora Sea renders navigation somewhat difficult. The current flows with the velocity of about one and one half nautical miles an hour, but the velocity may attain a maximum of five nautical miles in a strong northern gale.

The fortifications consist of the four Dardanelles castles. Of these, the Sedil-Bahr and Kale-Sultanije were built in 1462 by Sultan Mohammed II; Kum-Kale and Kilid-Bahr, the so-called new Dardanelles castles, were built in 1659 by the Grand Vizier Achmed Köprüli. These are huge masonry structures which have been subject to considerable reconstruction. They are armed with old heavy guns and are partly in ruin. In addition to these there are a few small old forts.

The newer fortifications, batteries, or forts in the Tschanak Narrows were built at the instance of England between 1864 and 1877. They consist of the Namazigia group (three earth batteries southwest of Kilid-Bahr), Dzirmen-Bruus (an earthen battery) on the European side, and Medjidije (a fort) and Nagara (an old stone fort, a newer fort of earth, and two batteries) on the Asiatic side. These works have been armed for the most part with more or less modern Krupp guns and were amplified in 1886 by smaller works. In 1892 the system of obstructions were strengthened with 150 sea mines. The defenses have in recent years been somewhat modernized and provided such modern equipments as telegraph, telephone, etc. The entire fortifications are said to contain 682 guns, about one half of which are more or less modern. The modern defenses are very well equipped and manned, so that a passage could be forced only with heavy sacrifices.

As part of the Dardanelles defenses, the line at Bulair must be mentioned. This is a land defense in the north of the peninsula, 5 kilometers long, consisting of three forts each with twelve to fifteen guns, and connecting lines, intermediate batteries, and advanced redoubts (together over one hundred guns). This line of Bulair protects the mainland from attack.

—*Scientific American.*

## II

### ANNOUNCEMENTS BY THE BRITISH ADMIRALTY AND FRENCH MINISTRY OF MARINE*

### FEBRUARY 19

Yesterday (February 19th) at 8 A. M., a British fleet of battleships and battle-cruisers, accompanied by flotillas, and aided by a strong French squadron, the whole under the command of Vice-Admiral Sackville H. Carden, began an attack upon the forts at the entrance to the Dardanelles.

The forts at Cape Helles and Kum Kaleh were bombarded with deliberate long-range fire. Considerable effect was produced on two of the forts. The others were frequently hit, but being open earthworks, it was difficult to estimate the damage. The forts, being outranged, were not able to reply to fire.

At 2:45 P. M. a portion of the battleship force was ordered to close and engage the forts at closer range with secondary armament. The forts on both sides of the entrance then opened fire, and were engaged at moderate ranges by *Vengeance, Cornwallis, Triumph, Suffren, Gaulois, Bouvet*, supported by *Inflexible* and *Agamemnon* at long range. The forts on the European side were apparently silenced. One fort on the Asiatic side was still firing when the operation was suspended owing to failing light.

No ships of the Allied Fleet were hit. The action has been renewed this morning after aerial reconnaissance. His Majesty's aeroplane ship *Ark Royal* is in attendance with a number of seaplanes and aeroplanes of the Naval Wing. (London, *February 20th*).

### FEBRUARY 20-28

Unfavorable weather with low visibility and a strong south-westerly gale has interrupted the operations at the Dardanelles. The outer forts were seriously damaged by the bombardment of the 19th. (London, *February 23rd.*)

The weather moderating, the bombardment of the outer forts of the Dardanelles was renewed at 8 A. M. this morning (February 25). After a period of long-range fire a squadron of battleships attacked at close range. All the forts at the entrance of the Straits have been successfully reduced. The operations are continuing. (London, *February 25th.*)

The entrance to the Dardanelles was guarded by four principal forts, namely, Cape Helles Battery, Fort Seddul Bahr, Fort Orkhanieh Tabia, and Fort Kum Kalessi Tabia, which will be described for convenience as A, B, C, and D. These forts are armed as follows:—A, two 9.2-inch guns; B, six 10.2-inch; C, two 9.2-inch; and D, four 10.2-inch and two 5.9-inch.

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*Taken from the *United Service Gazette* (London).

The weather having improved, although the wind was still from the southwest, the attack on the above forts was resumed on Thursday morning [February 25th] at 10 A. M. The *Queen Elizabeth, Agamemnon, Irresistible,* and *Gaulois* began by deliberately bombarding Forts A, B, C, and D, respectively, at long-range. Fort A replied, and one shell at 11,000 yards hit the *Agamemnon,* killing three men and seriously wounding five. The *Irresistible* and the *Gaulois* made excellent practice on Forts C and D, while the *Queen Elizabeth* concentrated with great accuracy on Fort A, putting both of its guns out of action by about 11:30 A. M. The *Vengeance* and *Cornwallis* then ran in under cover of long-range fire and engaged Fort A at close range. The reduction of Fort A was completed, while Forts C and D opened a very slow, inaccurate fire. The *Suffren* and the *Charlemagne* next delivered an attack on Forts C and D, advancing to within 2000 yards of them. It was then seen that they were in no condition to offer effective resistance. The *Vengeance, Triumph,* and *Albion* were then ordered in to complete the reduction of the forts. All four were reduced by 5:15 P. M.

Mine-sweeping operations, covered by a division of battleships and destroyers, were immediately begun. The enemy set fire to the village at the entrance as darkness fell.

A report has also been received of the operations on the 26th. The Straits have now been swept up to four miles from the entrance. The *Albion* and *Majestic,* supported by the *Vengeance,* proceeded to the limit of the swept area and began an attack on Fort Dardanus (E) (four 5.9-inch guns), and some new batteries which have been erected on the Asiatic shore. Fire in reply was ineffective. After being shelled from inside the Straits, the enemy retired from the forts at the entrance, and during the afternoon demolishing parties were landed at Kum Kali and Seddul Bahr from the *Vengeance* and the *Irresistible.* Forts A, B and C were then completely, and Fort D partially, demolished. The enemy encountered in Kum Kali were driven out over Mendere Bridge, which was partially destroyed. Two new 4-inch guns concealed near Tombachilles were also destroyed. Four Nordenfelts covering the entrance were destroyed. Our casualties on the 26th were one killed and three wounded. The operations are proceeding. (London, *February 27th.*)

The operations in the Dardanelles are again delayed by unfavorable weather. A strong north-easterly gale is blowing with rain and mist, which would render long-range fire and aeroplane observations difficult. (London, *March 1st.*)

### MARCH 1-6

The operations in the Dardanelles were resumed at 11 o'clock on Monday morning [March 1st,] when His Majesty's ships *Triumph, Ocean* and *Albion* entered the Straits and attacked Fort No. 8 and the batteries at White Cliff. The fire was returned by the forts and also by field guns and howitzers. An air reconnaissance made by naval seaplanes in the evening reported that several new gun positions had been prepared by the enemy, but that no guns had been erected in them. The seaplanes also located a line of surface mines. During Monday night a force of mine-sweepers, covered by destroyers, swept within a mile and a half of Cape Kephez, and their work, which was carried out under fire, is reported to have been excellent. The casualties sustained during the day were slight, and amounted to only six wounded.

Four of the French battleships operated off Bulair, and bombarded the batteries and the communications. The operations at the entrance to the Straits already reported have resulted in the destruction of 19 guns ranging from 6-in. to 11-in.; eleven guns below 6-in.; four Nordenfeldt guns; and two searchlights. The magazines of Forts Nos. 6 and 3 were also demolished.

A further report received states that yesterday [March 2nd] the *Canopus, Swiftsure* and *Cornwallis* engaged Fort No. 8. A heavy fire was opened on them by Fort No. 9, together with field batteries and howitzers. Fort No. 9 was damaged and ceased firing at 4.50 P.M. The battleships withdrew at 5.30 P.M., and although all three ships were hit the only casualty was one man slightly wounded. Seaplane reconnaissance was impossible on account of the weather. Mine-sweeping operations continued throughout the night. The attack progresses.

The Russian cruiser *Askold* has joined the Allied Fleet off the Dardanelles. (London, *March 3rd.*)

The attack upon the fortresses of the Dardanelles was continued yesterday [March 3rd]. The Admiral has not yet reported the results obtained within the Straits.

Outside, His Majesty's ship *Dublin* demolished an observation station on the Gallipoli Peninsula, and His Majesty's ship *Sapphire* bombarded guns and troops at various points in the Gulf of Adramyti.

Six modern field guns near Fort B have been destroyed, bringing the total number of guns demolished up to 40.

French battleships have bombarded the Bulair Forts and wrecked the Kavack bridge. (London, *March 4th.*)

Further reports have now been received from Vice-Admiral Carden on the operations of March 3 and subsequent days. No action was possible on the 3rd till 2 P. M., when, although the weather was still unfavorable, *Irresistible, Albion, Prince George,* and *Triumph* resumed the attack on Fort Dardanus (E) and the concealed guns in its neighborhood. These were less active than before, and were dealt with by the ships with more certainty. A useful seaplane reconnaissance located several encampments and two permanent batteries.

On March 4 the weather became fine, and the sweeping and bombarding operations within the Straits continued steadily. Meanwhile demolition parties, covered by detachments of the Marine Brigade of the Royal Naval Division, were landed at Kum Kali and Seddul Bahr to continue the clearance of the ground at the entrance to the Straits. The party at Seddul Bahr discovered and destroyed four Nordenfeldts. Some skirmishing ensued on both banks, and the enemy were found to be holding the villages in force. On this day, also, further down the coast *Sapphire* silenced a battery of field guns north of Dikili in the Gulf of Adramyti, and the defenses of Besika were shelled by *Prince George.* The following casualties were sustained on the 4th: 19 killed, 3 missing, 25 wounded.

On March 5 the attack was begun by indirect fire from *Queen Elizabeth* upon the defenses at the Narrows. This attack was supported in dealing with howitzers by *Inflexible* and *Prince George.* Fire was confined to forts Rumilieh Medjidieh Tabia, Hamidieh II Tabia, and Namazieh (marked on the Admiralty Map J., L., and T.), which are armed as follows:

| | | | | | |
|---|---|---|---|---|---|
| J. | 2 11-in. | L. | 2 14-in. | T. | 1 11-in. |
| | 4 9.4-in. | | | | 1 10.2-in. |
| | 5 3.4-in. | | | | 11 9.4-in. |
| | | | | | 3 8.2-in. |
| | | | | | 3 5.9-in. |

*Queen Elizabeth* fired twenty-nine rounds with satisfactory results. The magazine in Fort L., which is an important fort armed with the best and heaviest guns, blew up. The other two forts were damaged. The fire of the *Inflexible* and *Prince George* was observed from inside the Dardanelles by *Irresistible*, *Canopus*, *Cornwallis*, and *Albion*. Although these vessels were much fired at by concealed guns they were not hit. *Sapphire* again fired on troops in the neighborhood of the Gulf of Adramyti, and destroyed a military station at Tuzburna.

On March 5 also the Commander-in-Chief, East Indies, Vice-Admiral Sir Richard Peirse, arrived with a squadron of battleships and cruisers off Smyrna. A methodical bombardment of Fort Yenikale was carried out during the afternoon for two hours in favorable conditions of weather. Thirty-two hits were secured, inflicting considerable damage on the fort, and there were two heavy explosions, apparently of magazines. *Euryalus*, which flew the flag of the Vice-Admiral, shot with remarkable accuracy from her after 9.2-in. guns. Fire was not returned.

The bombardment at closer range has now begun, the weather conditions being good. The reduction of the Smyrna defenses is a necessary incident in the main operation. (London, *March 6th.*)

The operations against the Dardanelles are progressing, favored by fine weather. Vice-Admiral Carden reports that on March 6 *Queen Elizabeth* supported by *Agamemnon* and *Ocean*, began to attack Forts Hamidieh I. Tabia and Hamidieh III. (marked on the Admiralty Map U and V) by indirect fire across the Gallipoli Peninsula, firing at 21,000 yards (twelve miles). These forts are armed as follows:

| | | | | | |
|---|---|---|---|---|---|
| U.— | Two | 14-in. guns. | V.— | Two | 14-in. guns. |
| | Seven | 9.4-in guns. | | One | 9.4-in gun. |
| | | | | One | 8.2-in. gun. |
| | | | | Four | 5.9-in. guns. |

*Queen Elizabeth* was replied to by howitzers and field guns, and three shells from field guns struck her without causing any damage. Meanwhile, inside the Straits, *Vengeance*, *Albion*, *Majestic*, *Prince George*, and the French battleship *Suffren* fired on Suandere and Mount Dardanus batteries (marked F and E on Admiralty Map), and were fired on by a number of concealed guns. Fort Rumili Medjidieh Tabia (marked J on Admiralty Map), which had been attacked on the previous day, opened fire, and was engaged and hit by 12-inch shells. The majority of the ships inside were struck by shells, but there was no serious damage and no casualties. On March 7, the weather continuing calm and fine, four French battleships (*Gaulois*, *Charlemagne*, *Bouvet*, and *Suffren*) entered the Straits to cover the direct bombardment of the defenses of the Narrows by *Agamemnon* and *Lord Nelson*. The French ships engaged Mount Dardanus battery and various concealed guns, silencing the former. *Agamemnon* and *Lord Nelson* then advanced and engaged the forts at the Narrows at 14,000 to 12,000 yards by direct fire.

Forts Rumili Medjidieh Tabia (J) and Hamidieh I. Tabia (U) replied. Both were silenced after heavy bombardment. Explosions occurred in both forts. Fort L has not fired since the explosion on the 5th. *Gaulois, Agamemnon,* and *Lord Nelson* were struck three times each. Damage not serious. *Lord Nelson* had three men slightly wounded. While these operations were in progress the *Dublin* continued to watch the Bulair Isthmus. She was fired at by 4-inch guns, and struck three or four times.

Owing to the importance of locating the concealed guns the seaplanes have had to fly very low on occasions. On the 4th inst. a seaplane (pilot, Flight-Lieutenant Garnett; observer, Lieutenant-Commander Williamson) became unstable and nose-dived into the sea, both officers being injured. Flight-Lieutenant Douglas, reconnoitering at close quarters in another seaplane, was wounded, but managed to return safely.

On the 5th seaplane No. 172 (pilot, Flight-Lieutenant Bromet, with Lieutenant Brown) was hit no fewer than twenty-eight times, and seaplane No. 7 (pilot, Flight-Lieutenant Kershaw, with Petty Officer Merchant) eight times, in locating concealed positions.

The *Ark Royal* is equipped with every appliance necessary for the repair and maintenance of the numerous aircraft she carries. (London, *March 8th.*)

The Commander-in-Chief, East Indies, Sir Richard Peirse, has made a further report on his operations before Smyrna, from which it appears that, having bombarded Fort Yeni Kale on the 5th and severely damaged it, he proceeded on the morning of the 6th to sweep his way in through the minefields until he drew the fire of several subsidiary batteries, one containing four 6-inch guns near Paleo Tabia Point, another five approximate 4.7-inch guns 150 feet up the hillside, and three field guns in earthworks at Chiflik Guardhouse. There were also several smaller guns concealed along the shore to the eastward. These were engaged by the ships at from 7000 to 8000 yards.

The batteries replied vigorously, but after one hour's fire on each were silenced. In the afternoon the ships steamed into closer range and engaged Paleo Tabia battery and other batteries on the hill. Fire was continued until all were silenced. *Euryalus* and one of the battleships were each hit by 6-inch projectiles, and the mine-sweepers were hit by fragments of shell that burst near.

Our casualties were slight. The operations are continuing. (London, *March 8th.*)

### MARCH 7-8

Four French battleships, the *Suffren, Gaulois, Charlemagne,* and *Bouvet,* and two British battleships, the *Agamemnon* and *Lord Nelson,* yesterday entered the Dardanelles. While the battleships at long range bombarded the forts in the Narrows, which separate Chanak from Kilid Bahr the French battleships covered them by shelling the batteries at Dardanus and Souandere and hidden guns, which were silenced. Fort Rumeli Medjidieh Tabia, on the European side, and Hamidieh Tabia, on the Asiatic side, replied to the fire of the English battleships, but were also destroyed. (Paris, *March 8th.*)

On the 8th inst. the *Queen Elizabeth,* supported by four battleships, entered the Dardanelles and bombarded with her 15-inch guns Fort Roumeli-Medjidieh-Tabia, situated south of the point of Kilid Bahr. Bad weather hindered operations. A telegram from Athens says: The cannonade directed by the Allies against the inner Dardanelles forts has been very disastrous for the Turks. The British and French ships for two hours concentrated their fire on Fort Kilid Bahr and the Erenkeui batteries, which were badly damaged. One of the Erenkeui batteries was silenced, being completely overthrown by the first few shells fired. The heavy guns of the attacking ships next fired 76 shells on Fort Dardanus with entire success. The fire of the Turkish forts is becoming weaker and weaker. (Paris, *March 9th.*)

### MARCH 9-18

Minesweeping having been in progress during the last ten days inside the Straits, a general attack was delivered by the British and French fleets yesterday morning (March 18) upon the fortresses at the Narrows of the Dardanelles. At 10:45 A. M. *Queen Elizabeth*, *Inflexible*, *Agamemnon*, *Lord Nelson* bombarded Forts J, L, T, U, and V, while *Triumph* and *Prince George* fired at batteries F, E, and H. A heavy fire was opened on the ships from howitzers and field guns.

At 12:22 the French squadron, consisting of *Suffren*, *Gaulois*, *Charlemagne*, and *Bouvet* advanced up the Dardanelles and engaged the forts at closer range. Forts J, U, F, and E replied strongly. Their fire was silenced by the ten battleships inside the Straits, all the ships being hit several times during this part of the action.

By 1:25 P. M. all the forts had ceased firing. *Vengeance*, *Irresistible*, *Albion*, *Ocean*, *Swiftsure*, and *Majestic* then advanced to relieve the six old battleships inside the Straits.

As the French squadron which had engaged the forts in the most brilliant fashion was passing out, *Bouvet* was blown up by a drifting mine and sank in 36 fathoms north of Aren Kioi village in less than three minutes.

At 2:36 P. M., the relief battleships renewed the attack on the forts, which again opened fire. The attack on the forts was maintained while the operations of the minesweepers continued.

At 4:09 *Irresistible* quitted the line listing heavily; and at 5:50 she sank, having probably struck a drifting mine. At 6:05 *Ocean* also having struck a mine, both vessels sank in deep water, practically the whole of the crews having been removed safely under a hot fire.

The *Gaulois* was damaged by gun fire. *Inflexible* had her forward control position hit by a heavy shell, and requires repair.

The bombardment of the forts and the minesweeping operations terminated when darkness fell. The damage to the forts effected by the prolonged direct fire of the very powerful forces employed cannot yet be estimated, and a further report will follow.

The losses of ships were caused by mines drifting with the current which were encountered in areas hitherto swept clear, and this danger will require special treatment.

The British casualties in *personnel* are not heavy, considering the scale of the operations; but practically the whole of the crew of the *Bouvet* were lost with the ship, an internal explosion having apparently supervened on the explosion of the mine.

The *Queen* and *Implacable*, which were despatched from England to replace ships' casualties in anticipation of this operation, are due to arrive immediately, thus bringing the British Fleet up to its original strength.

The operations are continuing, ample naval and military forces being available on the spot.

On the 16th inst. Vice-Admiral Carden, who has been incapicitated by illness, was succeeded in the chief command by Rear-Admiral John Michael de Robeck, with acting rank of Vice-Admiral. (London, *March 19th.*)

Unfavorable weather has interrupted the operations in the Dardanelles, and, as seaplane reconnaissance has not been possible, the amount of damage done to the forts by the bombardment of the 18th cannot be ascertained. No great expectations should, however, be based on this, as, owing to the losses caused by drifting mines, the attack was not pressed to its conclusion on that day. The power of the Fleet to dominate the fortresses by superiority of fire seems to be established.

Various other dangers and difficulties have to be encountered, but nothing has happened which justifies the belief that the cost of the undertaking will exceed what has always been expected and provided for.

The British casualties in *personnel* are 61 killed, wounded, and missing.

Admiral De Robeck has telegraphed to the Admiralty as follows:

"I desire to bring to the notice of their Lordships the splendid behavior of the French Squadron. Their heavy loss leaves them quite undaunted. They were led into close action by Rear-Admiral Guépratte with the greatest gallantry." (London *March 21st.*)

## III

## ANNOUNCEMENTS FROM PETROGRAD CONCERNING THE BOSPHORUS*

On March 7 our fleet bombarded Zulguldak, Kozlou, Kilimli, destroying all structures and plant for the output and shipment of coal.

The bombardment was followed by a terrific explosion and fire. Four batteries were silenced. Eight steamers and a large sailing vessel were destroyed. Our casualties were three wounded. (Petrograd, *March 8th.*)

The Black Sea fleet yesterday bombarded the outside forts and batteries of the Bosphorus on both sides of the Straits.

According to observations made from the ships and hydroplanes, the shells fell with exactitude.

The Russian aviators flying above the Bosphorus batteries carried out reconnaissance and dropped bombs with success. A heavy artillery fire was poured on to the aviators, but without success.

The enemy's torpedoboats which tried to come out were driven back into the Straits by the fire of our guns. (Petrograd, *March 28th.*)

## IV

## INFORMATION FROM OTHER SOURCES

### THE NARROWS†

The reduction of the forts at the mouth of the Dardanelles was an easy task compared with that now undertaken at the Narrows. On the western bank, the Namazieh Battery, a little to the southward of Kilid Bahr (the Key of the Sea), guards the European side of this neck. Here

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*Taken from the *United Service Gazette* (London).

†Taken from *The Army and Navy Journal.*

also there is an ancient stone castle similar to those at the entrance to the Straits. Half a mile beyond Kilid Bahr is the Dermaburnu battery, and a mile further on still is Fort Cham, and there are still two other batteries between this and the village of Maidos. Beyond this village the coast makes an almost rectangular bend to the north and east, and at the top of this bend, facing right down the Narrows, is the fortress of Bokali, the guns of which can rake the channel. On the Asiatic side of the Narrows, just below Fort Chanak, is Fort Hamidieh, at the northern end of Sari Siglar Bay, and between Chanak and the battery at Nagara there are at least two other forts. The Nagara battery, overlooking the roadstead of the same name, is built on the site of the ancient castle of Abydos. It was apparently in the roadstead of Nagara that the *Messudiyeh* was lying when she was torpedoed by Lieutenant Holbrook, V. C., in submarine *B-11*, after diving under five rows of mines. In addition to the batteries mentioned, there are earthworks, and probably altogether about a score of defensive positions will have to be reduced.

It is not probable that any of them have heavier guns than those that have already been attacked with success. The speedy destruction of the batteries at the entrance to the Straits will, in the opinion of the London *Times*, specially claim professional attention, and may oblige a reconsideration of some preconceived theories. The circumstances were entirely novel, and inasmuch as the guns in the ships outranged those in the forts, the latter were unable to inflict damage while receiving punishment from the huge bursting charges in the naval shells. It was these which eventually broke down resistance and destroyed the fortress guns and their personnel. It has yet to be seen if the inner forts can be attacked in the same way and with a similar result. (*March 20th.*)

## MARCH 18-MAY 6*

Up to the time of our going to press this week [April 10], there were still no official advices from either British, French or Russian sources, concerning actual bombardment in the Dardanelles. Unofficial reports from correspondents state that the bombardment of forts has gone on at different times, but few details of value have been given. A report sent from Athens early in the week to Berlin estimates at more than thirty thousand the number of Anglo-French troops which have been landed on the Island of Lemnos, near the entrance to the Dardanelles.

The only official statement relating to the operations at the Dardanelles is that from the French War Office dated April 8 which said: "The expeditionary corps to the Orient, which was placed under command of Gen. A. G. L. d'Amade and concentrated at Bizerta, a fortified seaport of Tunis, Africa, to perfect its organization, has effected the voyage of the Levant under the best of conditions. It had been ready since March 15 to aid the allied fleets and British expeditionary corps. In waiting it was deemed advisable not to prolong the stay of the troops aboard the transports, and for this reason the hospitality of Egypt was accepted. The French forces have been debarked at Alexandria and are installed at Ramleh, where they are resting and perfecting their organization and cohesion. They are ready to proceed without delay to any point necessary."

Admiral Williams, of the British navy, who returned from Turkey a few weeks ago and was formerly on duty with the Turkish navy assisting

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*Taken from *The Army and Navy Journal.*

in its reorganization, in speaking at Portsmouth, England, March 17, said, in part: "Any success the Allies' fleet would be able to achieve must be supported by a powerful military force on land." This is so obvious a proposition that it is difficult to understand why the Allies attacked by sea until they were prepared for joint military and naval operations. The Admiral suggested that the plan of campaign was to knock out and render ineffective one after another the forts on the European side of the channel, and so to command the other side, and thus establish a waterway to get oil, grain and munitions of war from and to Russia, and at the same time to be in a position to put pressure on Constantinople. His own opinion was that the mass of the Turkish people were in favor of the Allies, and that if the fleet got to Constantinople the Turks could no doubt drop their agreement with Germany and come over and assist the cause of the Allies.

From Berlin, April 7, it is stated the Turkish War Office gave out the following official statement on that date: "On April 4 the enemy's cruisers unsuccessfully bombarded the Turkish batteries at the western entrance to the Dardanelles. One cruiser was sunk by the fortress fire."

An unofficial report from the German Overseas News Agency of April 5 said that the British battleship *Lord Nelson* of 16,500 tons had been sunk by gun fire. This report has not been confirmed from any source and seems very doubtful in view of the prompt report of the British Admiralty of previous losses.

An unofficial report from Paris, April 7, says: "The Vali of Smyrna has refused to surrender the city and the allied fleets resumed the bombardment of the forts, which have been destroyed."

A despatch to the London *Times* from Mytilene dated April 1 says: "Owing to the weather and other reasons the Turks and Germans had time to strengthen greatly the positions on both sides of the Straits. They have a fair supply of artillery mounted in excellent positions which the Allies' naval guns cannot always reach. There is nothing to show that the absence of camaraderie between the German and Turkish officers has diminished the fighting efficiency of the army to any considerable extent. The Turk shows at his best in defensive operations and much hard fighting in which the Allies must suffer heavily may be expected before the Allies are able to train their guns on the Porte." (*April 10th.*)

Very little has been reported this week [April 17] concerning the operations of the Allies in the Dardanelles, and what little has been made public is unofficial. The London *Time's* Mytilene correspondent telegraphed on April 15 that "heavy general rains are falling in the Eastern Aegean and there is no doubt they are preventing operations in the Straits." The British torpedoboat destroyer *Renard*, it was reported, entered the Dardanelles April 13 on a scouting mission and ran up the strait at high speed for over ten miles, penetrating the waterway probably further than any of the British ships have yet done. A heavy fire was directed at her, but the destroyer, it is said, was not hit. The British battleship *London*, which followed the *Renard* into the strait, drew most of the enemy's fire. The batteries on the Asiatic side, especially the howitzers behind Eren-Keui, were reported active; but those on the European side it is said were quiet. The battery bombarded by the *Triumph* April 10 is apparently out of action permanently. Turkish advices claim that one British cruiser and a torpedoboat destroyer were seriously damaged by Turkish fire early in the week.

In a cable to the *New York Herald* of April 10 Admiral Bettolo, of the Italian navy, who has been Minister of Marine in several Italian Cabinets, is quoted as stating his belief that the Dardanelles can be forced and Constantinople captured. He admits, however, that the difficulties in the way of carrying out this project are naturally greater now than they were some years ago, because the defenses of the strait have been much improved under the supervision of German officers. The Admiral described at length the military and naval resources of the Turks, aided by the Germans, which he declared to be formidable. "Nevertheless," he continued, "warships can triumph in the end over land forces because the greater range of their guns enables them to destroy the coast batteries while they are in such a position that shells from the enemy's forts cannot reach them. One of the essentials to success in such an operation is the complete destruction of each fortification attacked and the annihilation of its garrison by the landing of troops." (*April 17th.*)

Although the official veil of secrecy is still [April 24] drawn over the actual operations of the Allies against the fortifications in the Dardanelles, unofficial reports of a reliable nature show that British and French transports have been arriving at the port of Mudros, on Lemnos Island, in the Aegean Sea, off the entrance to the Dardanelles Straits. The number of troops assembled is said to aggregate some 30,000. A renewal of the bombardment, to support a land attack, may now be heard of any day, and the attack will probably develop into the most serious yet undertaken. (*April 24th.*)

The reports from the Dardanelles are [May 1] so contradictory that it is impossible to give any authoritative statement as to the progress of the allied attack against the Turkish fortifications. The general attack was resumed April 26, the army at this time joining with the fleet in the operations, as they should have done at first. The disembarkation of the allied army on April 25, covered by the fleet, began before sunrise at various points on the Gallipoli Peninsula. An official despatch from London reports that it was completely successful in spite of serious opposition from the enemy in strong entrenchments protected by barbed wire. After hard fighting in difficult countries the Allies claim to have thoroughly made good their footing, with the effective help of the navy. An official despatch published at Cairo, April 27, says: "The allied forces under Gen. Sir Ian Hamilton have effected a landing on both sides of the Dardanelles under excellent conditions. Many prisoners have been taken and our forces are continuing their advance."

An official French statement issued on April 27 says: "Aided by the cannon of the French fleet and under the fire of the enemy our troops, infantry and artillery, succeeded in occupying the village of Kum Kaleh, on the Asiatic side, and have continued its occupation, despite seven counter attacks at night, supported by heavy artillery. We took five hundred prisoners, and the losses to the enemy appear to have been considerable. The general disembarkation of the allied forces continues under good conditions."

A British War Office statement issued April 29 declared the allied force now controls a line from one side to the other of the lower Gallipoli Peninsula. The announcement reads: "In the face of continual opposition the allied troops have now established themselves across the end of the

Gallipoli Peninsula, from a point northeast of Eski Hissarlik to the mouth of a stream on the opposite side. They also have beaten off all attacks at Sari Bahr and are steadily advancing. The Turks have made considerable preparations to hamper any landings. Wire entanglements under the sea, as well as on land, and deep pits with spikes at the bottom were among the obstacles overcome by the troops."

The Turks on their part admit the landing on Sunday at four points on the west coast of Gallipoli, namely, at the mouth of the Sighindere, on the coast in the district of Avi Burnu, to the west of Gaba Tepe and on the coast at Teke Burnu and also in the neighborhood of Kum Kaleh, on the Asiatic coast. They claim, however, that the Allies only made good their footing at Gaba Tepe, saying: "The troops of the enemy which landed at Teke Burnu were forced to retreat at the point of the bayonet and were pushed back to the coast. A part of these forces on Monday night were obliged hastily to return to their ships. The Turkish attacks at all points are progressing successfully. Simultaneously a fleet approached the Dardanelles in order to force the Straits from the sea, but it was obliged to retreat before our fire. The forces of the enemy which landed at Kum Kaleh advanced under the protection of warships, but despite a heavy bombardment from all sides our troops drove them back to the coast. The enemy lost 400 men killed and 200 taken prisoners. Our losses were insignificant. A party of Moslem soldiers who landed with the French troops on this point of the coast deserted the French and joined our forces. Before Gaba Tepe we captured a number of English and Australian soldiers, among them a captain and a lieutenant. When the enemy's fleet approached the Straits our fire sank one of their torpedoboats and damaged another so severely that it had to be towed to Tenedos. The enemy did not undertake any operations from the sea against the Dardanelles on the following day."

A report on April 28 states that the Turkish aviators discovered that two battleships of the enemy's fleet had been badly damaged by the Dardanelles forts. There is no reliable statement of the forces engaged at the Dardanelles. The latest British official statement says the land forces succeeded in establishing a line across the Gallipoli Peninsula, near its western extremity, and were advancing steadily. (*May 1st.*)

Operations on the Gallipoli Peninsula by the allied troops and warships are [May 8] progressing, and British troops early in the week were in possession of five important positions on the European side of the peninsula, while the French troops occupied Kum Kaleh, on the Asiatic side. The French troops, which, it is believed, were landed at the latter point to create a diversion, were later retired after severe fighting and recrossed the Straits to join the main force. A very full report of the operations was issued by the British War Office on May 1, which covered the operations up to April 29. In brief the results of the fighting up to April 29 were the capture of Sedd-ul-Bahr and Kum Kaleh and the sinking of a Turkish transport near the Narrows and progress overland to that place. The report, in telling of the disembarkation before sunrise April 25, says, in part:

"The result of the first day's operations was the establishment of strong British, Australian and French forces at three points, namely, the Australian and New Zealand troops on the lower slopes of Sari Bair, to the north of Kaba Tepe; of British troops at Cape Teke, at Cape Helles and near Morto

Bay, and of a French force on the Asiatic shore at Kum Kaleh after a gallant attack toward Yeni Shehr. During the afternoon of April 25 strong counter attacks by the enemy began and hard fighting took place. Meanwhile the disembarkation of the army proceeded and was continually favored by good weather. At daybreak on the 26th the enemy was still holding the village and position of Sedd-ul-Bahr, which was a labyrinth of caves, ruins, trenches, pits and entanglements. Aided by the gunfire of the fleet this position was stormed by the British in frontal attack through undamaged wire entanglements. Sedd-ul-Bahr was taken about two o'clock in the afternoon, four pompoms being captured. The situation at this end of the peninsula was definitely secured and the disembarkation of French and British forces proceeded."

The report then tells of the successful advance on April 27 to near Krithia and the establishment of an intrenched line. The desperate but unsuccessful attempts of the Turks to drive the Australian and New Zealand troops from Sari Bair is told in detail, as well as the capture of 500 Turks by the French at Kum Kaleh, who repelled five attacks.

The report further says: "The casualties in the army necessarily have been heavy. The casualties in the fleet were not numerous. They appear to have been confined to torpedoboat destroyers and to boats' crews engaged in landing operations, in which merchant captains and officers and crews of transports also have taken part. On April 28 and 29 the allied forces rested and improved and consolidated their positions and continued the disembarkation of stores and artillery. All counter attacks by the enemy, which were incessant on April 28, but weaker on the 29th, were repulsed. The fleet, as well as the supporting army, has begun to engage the batteries. The *Triumph* bombarded Maidos, which was in flames April 29."

A statement from the British War Office of May 4 tells of further progress in advancing into the interior.

The warships are shelling the forts incessantly in relays, according to unofficial reports, which also state that Turkish forts on the Gulf of Smyrna have been bombarded and that troops of the Allies have landed at Ephesus, thirty-five miles south-southeast of Smyrna.

An Associated Press correspondent who was permitted to visit the Dardanelles region on May 1 says the town of Dardanelles was still ablaze and the scene was one of desolation. Maidos was also burned and the town of Gallipoli was burning, all by indirect fire from the warships in the Gulf of Saros, with ignition shells directed by captive balloons and aeroplanes. Incessant and heavy fighting has continued, the correspondent says, from the first landing of the Allies, but details of the campaign for military reasons are not permitted.

A despatch from Constantinople via Berlin and London May 6 from the Turkish War Office says: "The unfavorable situation of the enemy at the Dardanelles is unchanged. Reports from Athens and Mitylene regarding the occupation of Gallipoli and Nagara by landing troops of the Allies are untrue. Gallipoli peninsula is entirely at our disposal for military movements. The enemy holds his own at only two points on the coast, Avi Burnu and Sedd-ul-Bahr. As a result of the constant bombardment by his ships the enemy is unable to move against the encircling Turkish forces. The Asiatic shore has been cleared of the enemy." (*May 8th.*)

### V

### Resume

The magnitude of the efforts being made at the Dardanelles can be surmised by studying the list of ships engaged. Relying solely on official reports and leaving out of account the three vessels which have been lost, we find mention made of the following ships: British: the super-dreadnought *Queen Elizabeth*, the battle-cruiser *Inflexible*, the battleships *Lord Nelson* and *Agamemnon*, *Swiftsure* and *Triumph*, *Cornwallis*, *Queen* and *Implacable*, *Vengeance*, *Albion* and *Canopus*, *Prince George* and *Majestic*, the armored cruiser *Euryalus*, the light cruisers *Dublin*, *Sapphire* and *Amethyst*, and the seaplane carrier *Ark Royal;* French: the battleships *Suffren*, *Gaulois*, *Charlemagne*, *Henri IV.* and *Jauréguiberry* and the armored cruiser *D'Entrecasteaux;* Russian: the light cruiser *Askold*. The presence of others is implied, although they are not named, and we know, too, that this formidable fleet is supplemented by destroyers, mine-sweepers and other craft. During the month [March] actual bombardments on a serious scale were carried out on the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, and 18th. The last-named date witnessed probably the severest attack, and it was on this occasion that the three battleships were lost. What damage was done to the forts has not as yet been officially ascertained, but in the course of the earlier operations much good work was done against the defenses of the Narrows. One of the most notable features of the attacks has been the work of the *Queen Elizabeth*. This vessel on several occasions has bombarded the inner forts by indirect fire across the Gallipoli peninsula at ranges reaching up to 21,000 yards. On the 5th she fired twenty-nine rounds in this manner at three of the forts. The magazine of one of these, an important fort armed with two 14-inch guns, was blown up, and the fort has not fired since. The exploit of the small cuirser *Amethyst* is also worthy of record. This vessel on the night of the 13th made a dash at full speed up the Straits as far as Nagara—that is to say, almost to the inner end of the Dardanelles—where, if report be true, she cut the submarine telegraph cable. She returned safely, but her casualties were heavy, amounting to twenty-three killed and thirty-seven wounded. Meanwhile, the Russian Black Sea fleet has approached the Bosphorus, and on the 28th carried out a vigorous naval and aerial attack on the forts at the entrance.—*The Engineer.*

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## SEARCHLIGHTS

### By C. S. McDowell

Searchlights were first used during the Civil War in a very crude state; these first searchlights were fitted with metal mirrors. Later, Fresnel lenses were used to concentrate the beam. In 1876, the Mangin type of mirror was first brought out; and in 1886, Schuckert, in Nuremburg, succeeded in producing a glass parabolic mirror ground to mathematical accuracy. Practically no changes have been made since that time to increase the efficiency of the searchlight; some mechanical improvements have been made, and methods of manufacture of carbons perfected, but practically the ordinary searchlight of to-day is the same as that of twenty-five years ago.

In view of the increasing speed of torpedoboat destroyers and the increased range of torpedoes, it is very important that the searchlight, one of the principal means of defense against night attack, should be improved if possible. There has lately been developed by Mr. Heinrich Beck of Germany, a new type of searchlight much more efficient than those now in use, which is described a little later in this paper.

In considering the question of searchlights and their relative efficiencies, it becomes natural to consider them as made up of the following constituent parts:

1. Searchlight drum, pedestal, system of control in azimuth and in elevation, shutters and other purely mechanical details.
2. Rheostats.
3. Searchlight mirror.
4. Lamp mechanism.
5. Searchlight arc.

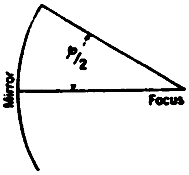
One type of searchlight may show increased efficiency over another because some of these parts have been worked out to give the very best results, but a searchlight to give the very best results must have all these details worked out separately and then joined together in the proper relation to give the maximum efficiencies.

Searchlight drum and other mechanical details are questions of design, which affect the efficiency of the light very little. They should be worked out carefully, however, so that the searchlight is properly balanced, may be easily trained in azimuth and elevation from a distant control station or at the light itself. The drum should be so made that air currents cannot be set up inside, thereby causing flickering of the arc; ventilation should be sufficient so that light may be kept on at full intensity with shutter closed, or other means adopted for keeping the light burning at lower intensities with shutter closed and bringing it to full intensity instantly upon opening of shutter. It is also considered advantageous to have a permanent ammeter and voltmeter mounted on the searchlight drum, or a connection on it so that portable instruments can be connected. A ground-glass finder which shows the position of the arc, the arc length, and the variations of the positive crater from the focus of the mirror, is considered an essential in a properly designed searchlight. The mirror should be so secured that it may be readily removed, and the mirror and front door strips should be mounted in such a manner as to eliminate shock and breakage.

The rheostat used in connection with searchlights consists of two parts: a fixed and a variable resistance. A certain amount of fixed resistance is necessary to overcome the natural instability of a carbon arc, and its value must be at least sufficient to give a voltage drop in the resistance equal to one-half the arc stream voltage. The variable resistance is necessary in order to obtain the proper arc voltages for various carbons and various lengths of line. The resistance elements must be of sufficient area to carry the maximum currents used without undue heating of any parts, and of such material that the resistance does not change excessively with temperature changes. The steps should be not greater than one volt each.

The efficiency of a searchlight mirror depends upon its trueness to parabolic form, its trueness of surface grinding, the color and structure of the glass, and the thickness of the glass. The losses in searchlight mirrors are due to stray rays outside of the conical beam and to absorption in the mirror. The intensity of illumination on a distant object, provided equal amounts of light fall on the mirror, is dependent on the efficiency of the mirror and the angle of dispersion (that is, at a distance, the area of the illuminated plane normal to beam).

The relation between the focal length and diameter of the mirror should be such that the effective angle $\varphi$ should include the majority of light given off by the arc. By increasing the focal length, the diameter of mirror remaining constant, the ratio of the light falling on the mirror to the total given out by the arc is decreased, but also the angle of dispersion is decreased; therefore, the correct focal length is that which, changed in either direction, decreases the foot-candle illumination on a distant object. If we increase the diameter of the mirror at the same time as the focal length is increased, the angle $\varphi$ can be maintained constant and at the same time the dispersion decreased, thus giving greater intensity of illumination on a distant object. On board ship, however, the size of the searchlight, and thus the diameter of the mirror, is limited. A greater focal length is also of advantage in that it takes the arc farther from the mirror and thus decreases the chances of breakage of the mirror due to the heat of the arc.



1651

In determining the efficiencies of searchlight mirrors, various tests are carried out:

(*a*) *The Line or Screen Test.*—If we imagine a section taken through the center of the mirror, a curve is obtained whose curvature should vary in a regular manner from the center towards the edge, but the curve will take a wavy form instead, if the surface has not been accurately ground.

The mirror is erected opposite a screen on which are painted two systems of parallel straight lines at right angles to one another. The image of these lines is photographed by a camera placed back of the hole in the center of the screen. If both surfaces of the mirror are properly ground, the lines in the photograph should be regular, but not necessarily straight nor parallel. This test does not show if the mirror is parabolic or not.

An illustration of a mirror showing this test is given in Fig. 1.

(*b*) *The Sun or Zone Test.*—A perfect mirror should reflect rays from a point of light situated at its focus, in parallel straight lines. It must, therefore, also have the property of bringing a parallel beam of light, as from the sun, to a focus in a single point. This as made, consists in placing the mirrors in a plane perpendicular to the sun's rays and photographing the reflected focal point, brought out in contrast by blowing smoke on it.

An illustration of this test is shown in Fig. 2.

(*c*) *Beam Photometric Tests.*—It is considered that the most reliable

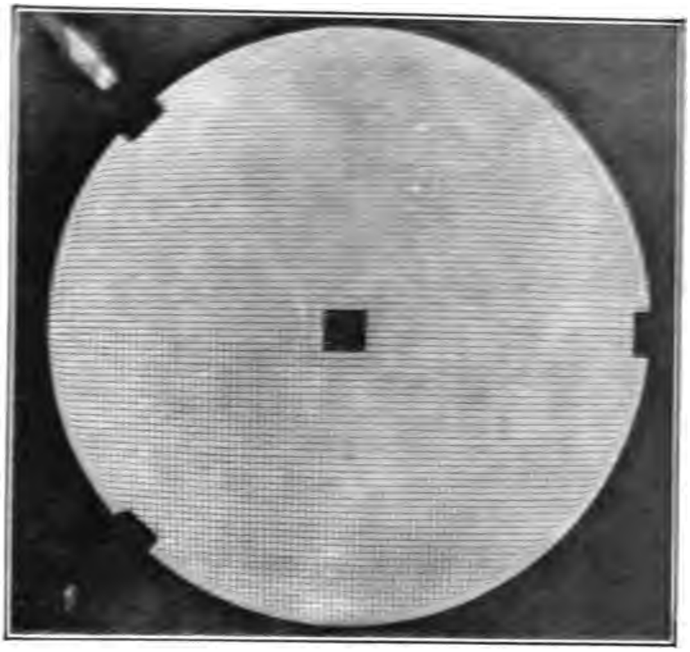


FIG. 1. 1652

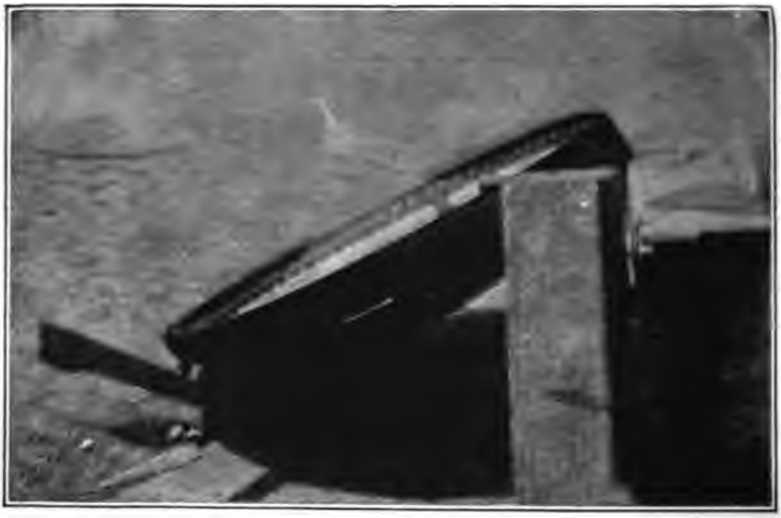


FIG. 2. 1653

test of mirrors is to actually mount them in a searchlight, place a constant source of light in the focus, and, at a standard distance, measure the actual foot-candles of illumination throughout the entire beam. The focal point of a mirror to be tested is first accurately obtained (our method being to place two mirrors exactly parallel with each other about 30 ft. apart and place a concentrated filament lamp approximately at the focal point of the second and measure accurately the focal length of the first); the mirror under test is then mounted in a searchlight frame held in a fixed position, a concentrated filament lamp placed accurately in the focus (a 50-watt lamp is used), and at a standard distance the foot-candles measured by a portable photometer. These foot-candle readings are usually obtained every four inches across the beam on two lines perpendicular to each other and passing through the center. For the larger size mirrors, 200 feet has been taken as the standard distance. Curves obtained in this test are shown in Fig. 3.

By calculating the amount of light flux falling on the mirror and that received on the distant object, the losses in the mirror may be found and the coefficient of reflection obtained.

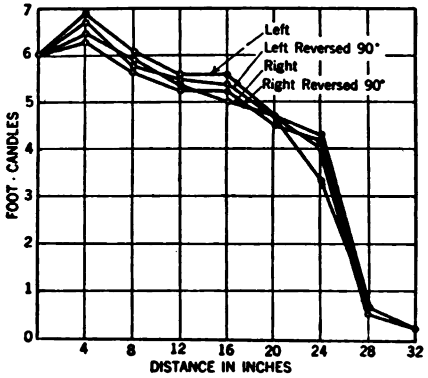


FIG. 3. 1654

Concentrated filament lamp test of the Navy standard 36-inch searchlight mirror taken in foot-candles at a distance of 200 feet. Fifty watt, 6-volt, concentrated filament lamp used.

In a number of cases, mirrors which showed nearly perfect grinding and sharp focal point, as determined by the first two tests, were found, on this third test, to reflect less light than other mirrors which had shown much poorer results on the screen and zone tests.

The lamp mechanism of a searchlight should be such as to keep the crater of the positive carbon at the focus of the mirror, should keep the arc length that which is desired, should carry the current of the carbons, should contain mechanism for rotating at least the positive carbons, should be sufficiently rigid to keep the carbons in proper allignment, and should require little care and adjustment.

An illustration of the Beck lamp mechanism is shown in Fig. 4. Both carbons are rotated for the purpose of keeping surfaces bathed in the inert gas and to keep the arc central and thus promote evenness of burning. The positive holder is fixed, the carbon being fed through it at such a rate [illegible] the mirror, the rate [illegible] small mirror being placed in the beam [illegible] small beam on a thermo- [illegible] thickness [illegible] the small beam of light is [illegible] down. In addition the feed [illegible] carbon feeds through the nega- [illegible] by hand. The negative [illegible] the arc, when it is moved [illegible]

[illegible] the Beck lamp mechan- [illegible] of the crater of the positive [illegible] noticeable; and the arc [illegible] maintaining the arc was [illegible] carbons; the crater of the positive carbon [illegible] there was no noticeable hissing and jumping of the arc. [illegible] the standard motor-controlled lamp

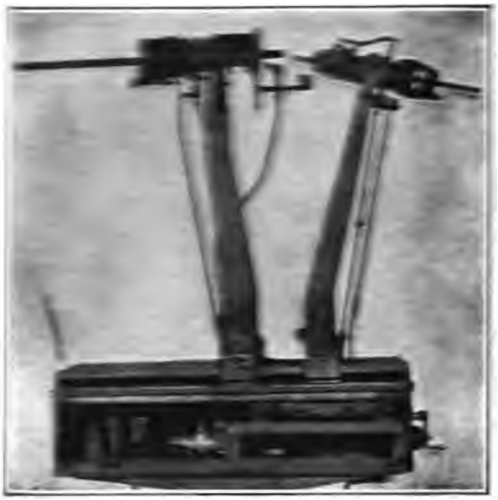


FIG. 4.

mechanism functioned successfully, maintaining practically a constant voltage, the arc length did not remain constant and the positive crater did not remain at the focus, due to the impracticability of constructing positive and negative carbons which will be consumed at a certain given ratio. Also the positive crater tended to wander over the surface of the positive carbon, with the result that one side would project and the other recede, causing a hissing arc and making it necessary, in order to obtain any consistent results, to shut off the light and turn the positive carbon by hand about every fifteen or twenty minutes.

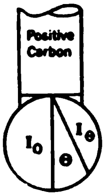
We now come to the arc, probably the most important part of the searchlight and also the one least understood. There have been numerous treatises written on the arc, but it has been always discussed from the general illuminating side and without much consideration of its uses for searchlights. Paragraphs have been written in some illuminating treatises on the searchlight arc, but it has in general been given scant attention. This is probably more or less natural, for the authors of these books were not especially interested in searchlights, and, as a rule, had had very little experience with the subject.

The desired searchlight arc should excel in the following particulars:

1. Small positive carbons with high current densities and thus high crater temperature throughout crater area, which gives high intrinsic brilliancy. Intrinsic brilliancy is the luminous intensity per unit area.
2. Small negative carbons.
3. Long arc length, that is, distance between positive crater and negative point.
4. Uniform mixture of carbon so as to help the evenness of burning.

The Beck searchlight may be considered as being especially designed to meet the above requirements, and therein lies its marked superiority over the searchlights now in use.

In a searchlight the angle of dispersion is directly dependent on the diameter of the source of illumination, provided the focal length is constant; and if the diameter of the source can be decreased one-half while the candle-power remains constant, the intensity of light on the target would be quadrupled. Actually in the Beck light, the positive carbon is reduced one-half and, at the same time, the candle-power is increased so that greater efficiencies are obtained.



To illustrate the effect of arc length on candle-power, it may be stated that with a circular plane radiator (the crater of the positive carbon approximates such a radiator) the maximum candle-power is obtained on the vertical axis of the radiator as shown by the sketch. Here we have $I_0$ = maximum intensity, and $I_\theta = I_0 \cos \theta$. Thus, the smaller the angle, the greater the maximum intensity of light falling on the mirror. With positive and negative carbons of a fixed diameter, the angle $\theta$ depends upon the arc length, being the angle of partial shadow on the mirror projected by the negative carbon cutting off, through this angle, the light rays emitted by the positive carbon. This may be more clearly expressed by the formulas,

$I_\theta = I_0 q \cos \theta$, where $I_0$ = the normal intensity as before;

$I_\theta$ = the intensity at any angle $\theta$ from the normal; and

$q = \dfrac{\pi r^2 - S}{\pi r^2}$, where $r$ = radius of positive carbon and

$S$ = the area of overlap of the negative on the positive for the angle $\theta$.

The light intensity is reduced by the shadow of the negative carbon only for those angles of $\theta$ which are smaller than $\tan\theta = \frac{r + r_1}{l}$, where

$r$ = radius of positive carbon,
$r_1$ = radius of negative carbon,
$l$ = arc length.

Thus it is seen that, to decrease the angle of shadow, it is necessary to increase arc length or decrease the diameter of negative carbon. The arc length is restricted to the stability point of burning.

In Fig. 5 is shown by curve the increase of candle-power with increase of arc length; the candle-powers are taken at 40° from the normal to arc surface and are approximately the maximum.

The arc length of the Beck lamp is maintained constant at about 7/8-inch, as compared to about 5/8-inch obtained at 60 volts in the standard 36-inch lamp.

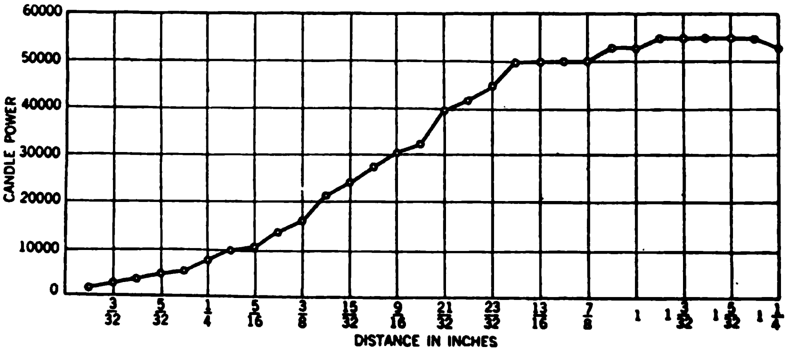


FIG. 5. 1657

Candle-power—arc-length curve taken at a point 40 degrees from normal to the arc surface. Navy standard carbons. Current normal 110 ampères.

Fig. 6 shows the variation of arc voltage with arc length as determined on a set of ordinary 36-inch carbons with constant current of 110 ampères.

It is, of course, well known that carbon is the most refractory of all known materials, boiling at about 4000 deg. Cent., but it unfortunately commences to evaporate at a much lower temperature (about 1800 deg. Cent.); so that in an ordinary arc very little of the total area of the end of the positive carbon is at the melting temperature, a small wandering spot being the real efficient part of the carbon, and the rest of the end of the carbon is consumed at a much lower temperature, giving off less intense rays and a longer wave length. This may be readily seen in comparison of the Beck and ordinary arc by the color of the arc.

In the Beck arc the ends of the positive and negative carbons are enveloped in the hydrocarbon vapors, which prevents the consumption of the carbons at a lower temperature, by keeping oxygen from them; in addition it cools the outer shell of the carbons, the gas being at a temperature of about 1000 deg. Cent., and thus concentrates the current in the center of the carbons; thus a current density greater than 0.75 ampères per sq. mm. is obtained, and the total crater of the positive carbon reaches a very high temperature. The current is brought to both carbons near the ends by roller contacts, so the only part having this high current density is the part protected by the indifferent gas. The positive carbon is cored with a rare earth with a melting point at about 3500 deg. Cent. The positive develops a deep crater, about 12 mm. deep, filled with incandescent gas. The sides of this crater reflect the light radiation to the focus of this crater and in addition, the light from the negative is reflected, so it is believed nearly true black body radiation is obtained; and by adjusting the focus of the crater to focal point of the mirror the high peak in the luminosity curve of the beam is thus accounted for.

The area of the Beck positive carbon is 201 sq. mm.; the area of the ordinary 36-inch light positive carbon is 805 sq. mm. In the Beck light the maximum intrinsic brilliancy is greater than 438 c.p. per sq. mm. The intrinsic brilliancy of an ordinary carbon arc varies from 120 c.p. per sq. mm. to 160 c.p. per sq. mm.

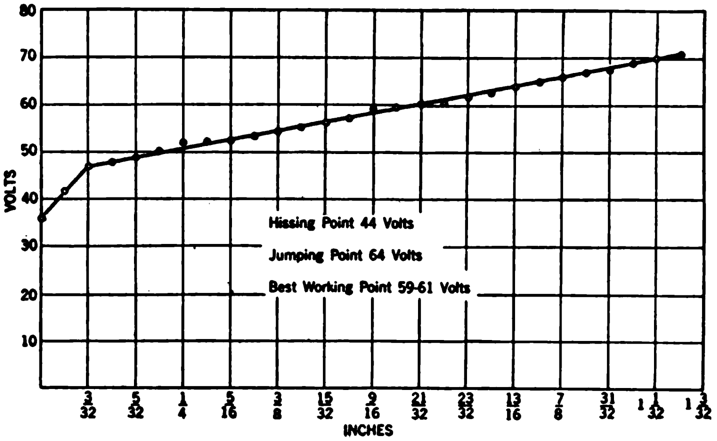


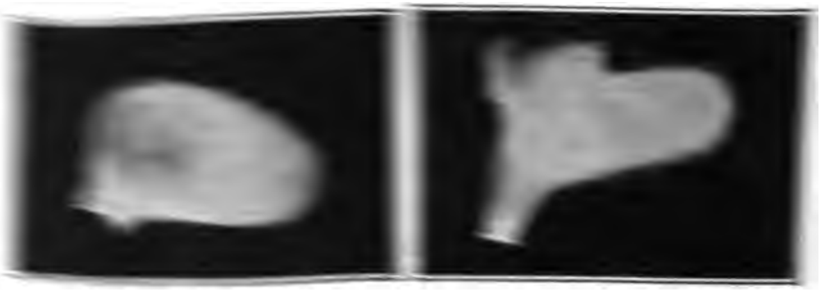
FIG. 6.

Arc-voltage—arc-length curve. Navy standard carbons used. Line current constant at 110 ampères.

In addition to the black body radiation obtained from the crater, there is evidently a large amount of light radiated from the incandescent gas in the crater, of a selective nature. It would probably at first be thought that this gas should follow Kirchhoff's laws and absorb the lines which they naturally radiated, giving the Fraunhofer lines seen in the sun's spectrum, but in this case the incandescent gas is at a higher temperature than the crater, and the spectrum shows positive lines apparently superimposed on the regular temperature radiation.

It is noticed that taking the Beck carbons and starting at a low current density, a luminous arc stream as of a typical white flame arc is obtained, the anode being convex. As the current density is increased, the anode becomes concave and the anode stream disappears, apparently being confined to the crater of the positive carbon, leaving only the lower temperature and less luminous cathode stream. The temperature of the incandes-

[illegible]



[illegible]

[illegible] sensation of the eye for the [illegible] spectrum, [illegible] sensation for some [illegible] spectrum. The shifting of the [illegible] is a well known phenomenon [illegible] the Purkinje effect. It is thus seen that the Beck light [illegible] where the illuminative [illegible].

It is a well-known fact that a colored body reflects the colors from [illegible] falling on it which the body itself contains, and absorbs the rays [illegible] contains; the Beck light, being strong in the short waves of light, would thus be particularly effective in picking up objects of a bluish color, such as the various classes of ships painted bluish gray.

An illustration is shown, Fig. 9, of the Beck light and of a standard 36-inch searchlight, the upper beam being that of the Beck light and the lower of the standard light.

Comparative night illumination tests were conducted between standard 36-inch and 60-inch searchlights and the 44-inch Beck searchlight. The Beck searchlight beam was a more concentrated beam than that obtained from either the 36-inch or 60-inch beam of the standard lamp and the color of the Beck beam was a whiter one than that obtained from the Navy standard 36-inch and 60-inch searchlights. With the carbons burning in a normal condition and placed in the proper focal centers of their respective mirrors, foot-candle-power readings at intervals of 24 ft. were taken across the beam at a distance of 2850 ft. from the searchlights. Figs. 10 and 11 show the illumination across the beam of the Beck searchlight compared with the 60-inch standard searchlight. From these two curves it can be seen that the maximum illumination obtained from the Beck light is approximately 2½ times as great as that obtained from the standard 60-inch. In the Beck searchlight the beam shows a very high illumination at the center and falls off very rapidly at the edge of the beam. The other figures, 12 and 13, were obtained in comparing the Navy standard 36-inch searchlight with the Beck light. The figure containing the results of the 36-inch standard searchlight consists of five curves; the curves indicated by 1, 3 and 4, are plotted from actual results obtained; curve 3 is a resultant of curves 1, 3 and 4, and curve 5 is obtained if a 44-inch Navy standard searchlight is used in place of a 36-inch light. The other figure with the results obtained from the Beck light contains 4 curves; 3 plotted from the actual results obtained, and curve number 4 is the resultant curve of these three. From the comparative data obtained, it can be seen that the illumination obtained with the Beck searchlight is about five times as great as that obtained from the standard light. The spherical candle power of the Beck arc was measured and the results obtained are shown in Fig. 14. The maximum candle-power

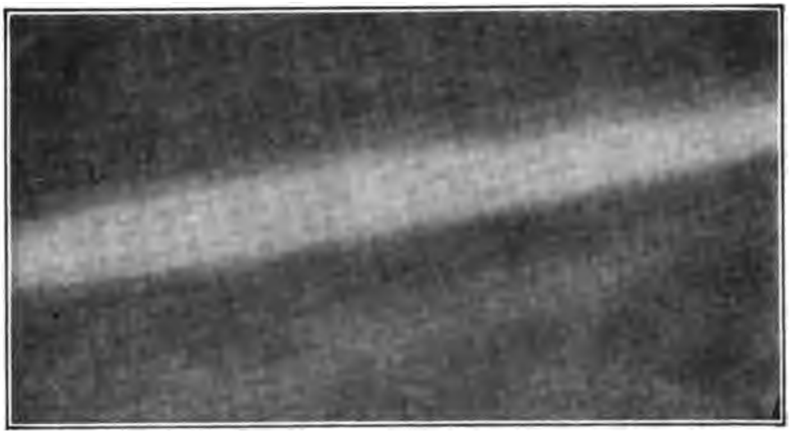


FIG. 9. 1661

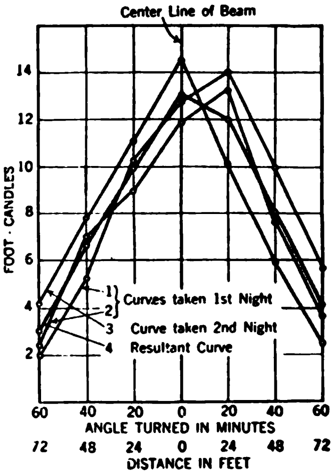


Fig. 13.

Foot-candle—power-distance curve of the Beck 44-inch searchlight taken at a distance of 2850 feet. Lamp burning under normal conditions.

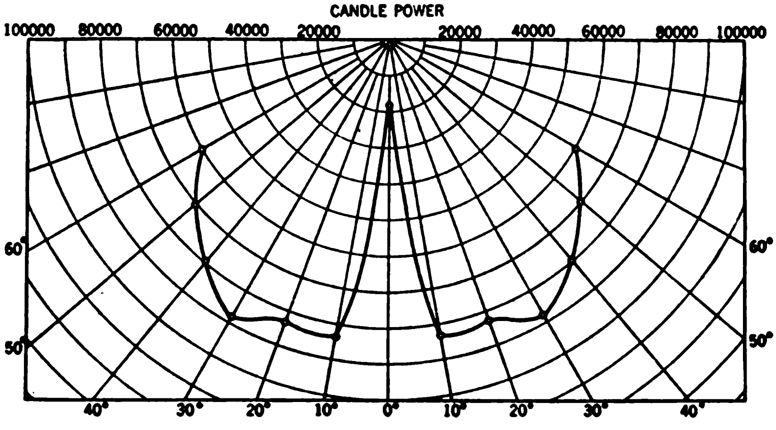


Fig. 14.

Candle-power distribution curve for the Beck searchlight lamp.

obtained with the use of our present Navy standard carbons is 45,000 candle-power, as against 88,000 candle-power obtained from the Beck lamp. A zonal candle-power curve of standard 36-inch carbon arc with arc voltage at 60 volts is shown in Fig. 15.

The results shown in Figs. 10, 11, and 13, are relative only, and cannot be used to determine the zonal candle-power of the beam reflected from the mirror. The absorption of the atmosphere would have to be taken into

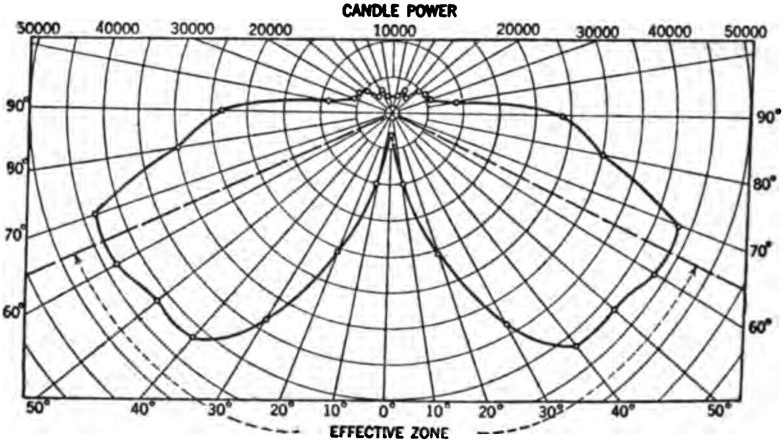


FIG. 15. 1667

Candle power distribution curve of Navy standard carbons. Line current, 110 ampères. Arc voltage, 60 volts. Arc length constant at 19/32-inches.

consideration to obtain the actual candle-power of the beam; the results obtained in Germany with this same light were much higher than those shown here, but the relative intensities between the ordinary arc and the Beck arc were approximately the same.

—*Proceedings of the American Institute of Electrical Engineers.*

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## EXTRACTS FROM THE BIMONTHLY ORDNANCE REPORT FOR MARCH-APRIL, 1915

### THE ORDNANCE BOARD

*Jump of 14-inch gun at 0° and 1° elevation.*—Found negligible.

*Device for retaining igniter opposite vent in base charges for mortars.*—Diameter of igniter increased and rods of powder placed along sides of bag recommended.

*Experimental forms of powder grain.*—Results indicate that slivers could be obviated and efficiency of powder increased. Further tests recommended.

*Thermit as a shell filler.*—Unsatisfactory.

*Storage and practical tests of gas check pads.*—Storage for one year produced no significant change. Tensile strength of threads of pad covering ununiform.

*Flake graphite and aquadag suspended in water as a substitute for hydrolene in sponging between rounds.*—Unsatisfactory.

### ROCK ISLAND ARSENAL

*Cartridge storage cases for 10-inch guns, models of 1895 and 1900.*—Sixty-eight experimental cartridge storage cases to contain single section charges are now being manufactured. These storage cases are to be fitted with carrying handles and are to have removable closures at each end to permit their being used as loading trays. Upon completion they will be shipped to several coast artillery posts for use in approaching target practice.

### WATERTOWN ARSENAL

*Elevation of 15° for 12-inch gun on disappearing carriage.*—Manufacture of three experimental elevating arms and three elevating bands for 12-inch disappearing carriage, models of 1896 and 1901, to permit firing at 15° elevation.

*Chamber sponge.*—Manufacture of one experimental chamber sponge for 10-inch gun, model of 1900.

*Attachment of gallery practice rifle to 12-inch gun.*—Manufacture of two sets of parts for attachment of gallery practice rifle to 12-inch disappearing carriages.

*700-lb. mortar shell.*—Manufacture of 1185 12-inch deck piercing shell, model of 1911, 700 pounds.

*Firing circuits for 12-inch barbette guns.*—Manufacture of 28 sets of parts for firing circuits and also magneto brackets for 12-inch barbette carriage, model of 1892.

### WATERVLIET ARSENAL

*New design circuit breaker for 10-inch and 12-inch guns.*—Manufacture of new design circuit breaker contact pieces for 10-inch and 12-inch guns, models of 1888, 1895 and 1900, to replace all in service.

*Increased elevation for 12-inch guns on disappearing carriages.*—Design and manufacture of fixture for cutting a groove in the jacket of 12-inch guns, models of 1888 and 1895, on disappearing carriages, for the purpose of securing a new design elevating band thereto to permit these guns to be given greater elevation.

*New design circuit breaker for 6-inch gun.*—Manufacture of new design circuit breaker contact pieces for 6-inch guns, model of 1897, to replace all in service.

# BOOK REVIEWS

*Our Navy and the Next War.* By R. W. Neeser. New York City: Charles Scribner's Sons. 5½" x 7¾". 205 pp. Cloth. 1915.

This is an admirable book, though its timeliness depends somewhat upon the point of view of the reader. Considering, as it does, national antagonisms resulting from differences of culture, race, and religion, and from commercial influences which will affect the future of the United States and that country's probable enemies, as arguments for an increased military establishment, it will probably prove unconvincing to those who deny the existence of the antagonisms or the probability of the enemies.

While it does not draw a comfortable picture of our readiness to meet attack, it is a sane, constructive study of our preparedness for war, pointing out the strength and weakness of our present system, and proposing specific plans for remedying the conditions found.

The condition of the American Navy is pointed out with great fairness. Its evolution and progress, its organization and administration, its personnel and its normal employment are elaborately described and subjected to an unbiased and fearless examination which throws light upon many points of the problem of securing the greatest efficiency of the whole.

Statistics and authorities, freely quoted throughout the book, give justification to the severe arraignment of the rival political parties which have permitted questions of national defense to become party issues and made the Navy a shuttlecock in their continual strife. Lack of a continuing policy of construction, haphazard building up of the naval forces without sufficient regard for expert opinion as to their probable use, reliance upon the power of the single ship, taking no account of the various accessories essential to the maintenance of a fleet, all emphasize the demand for technical authority in control of naval progress.

The suggestive chapter headings are: I. Our Situation; II. Our Diplomatic Position; III. Military Peace Preparation; IV. Naval Peace Preparation; V. Our Military Requirements; VI. Our Naval Requirements; VII. Military Policy; VIII. Naval Policy; IX. Naval Organization and Administration; X. The Employment of the Fleet; XI. The Personnel; and XII. Evolution and Progress. The contentions of the author are supported by the "Report of the General Board of the Navy Department" on the increase of the navy, by the "Report of the Personnel Board on Increased Efficiency of the Personnel of the Navy," and by a synopsis of our national pension waste under the title of "The Price of Unpreparedness," which appear in the Appendices concluding the work.

Notwithstanding that the book has many points of similarity with a number of the war books recently published which deal with the naval and military position of the United States, still it presents an additional argument which, it is to be hoped, will further arouse our citizens to a sense of the fallacy of the idea that to be unprepared for war is to avoid war. As such it has a real importance and a distinct value.

[illegible]

## Index to Current Military Literature

*PUBLISHED WITH THE*

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VOLUME 43

MARCH-APRIL, 1915

Fort Monroe, Virginia
COAST ARTILLERY SCHOOL PRESS
1915

# KEY

# TO

# INDEX TO CURRENT MILITARY LITERATURE

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The periodicals cited are arranged by government, and each periodical is assigned a symbol consisting of an initial, or other abbreviation of the governmental designation, and a numeral indicative of the periodical's position in an alphabetical arrangement of the JOURNAL OF THE UNITED STATES ARTILLERY's exchanges under that government.

Prices of subscription are given in the currencies of the countries of publication.

All the periodicals cited are preserved in the Library of the Coast Artillery School at Fort Monroe, Virginia.

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## ARGENTINE

| | | |
|---|---|---|
| *Ar-0.5* | *Anuario del Instituto Geografico Militar de la Republica Argentina*<br>3ª Division del Estado Mayor del Ejército<br>Buenos Aires | Annual |
| *Ar-1* | *Boletin del Centro Naval*<br>Florida 659,<br>Buenos Aires | Bimonthly<br>Per year $m/n11.90 |
| *Ar-2* | *Revista Militar*<br>Ministerio de Guerra, Santa Fe 1461<br>Buenos Aires | Monthly<br>Per year $m/n9.00 |

## AUSTRIA

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|---|---|---|
| *Au-1* | *Mitteilungen aus dem Gebiete des Seewesens*<br>Pola | Monthly<br>Per year 17 M |
| *Au-2* | *Mitteilungen ueber Gegenstaende des Artillerie-und Genie-Wesens*<br>Getreidemarkt 9<br>Wien, VI. | Monthly<br>Per year 21 M |
| *Au-3* | *Streffleurs Militaerische Zeitschrift zugleich Organ der militaerwissenschaftlichen Vereine*<br>I. Graben, 13. Wien | Monthly<br>Per year 28 M |
| *Au-3.5* | *Streffleurs Militaerblatt*<br>Verlag L. W. Seidel & Sohn, k.u.k<br>Hofbuchhandler, Wien | Weekly<br>Per year 16 M |
| *Au-4* | *Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*<br>I. Eschenbachgasse, No. 9<br>Wien | Weekly<br>Per year 34 K |

## BELGIUM

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|---|---|---|
| *Be-1* | *Belgique Militaire, La*<br>Rue Albert de Latour 50<br>Schaerbeck, Brussels | Weekly<br>Per year 12 fr 50 |
| *Be-2* | *Revue de l'Armée Belge*<br>24 Rue des Guillemins, Liege | Bimonthly<br>Per year 13 fr |

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| *Be–3* | *Revue de l'Ingénieur et Index Technique*<br>70, Boulevard d'Anderlecht, Brussels | Quarterly<br>Per year 30 fr |

## BRAZIL

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|---|---|---|
| *Br–1* | *Boletim Mensal do Estado Maior do Exercito*<br>Ministerio de Guerra<br>Rio de Janeiro | Monthly |
| *Br–2* | *O Tiro*<br>Rio de Janeiro | Monthly |
| *Br–3* | *Revista Maritima Brazileira*<br>Rua D. Manoel n. 15<br>Rio de Janeiro | Monthly<br>Per year 12$000 |

## CHILE

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|---|---|---|
| *C–1* | *Memorial del Estado Mayor del Ejercito de Chile*<br>Talleres del Estado Mayor-General<br>Santiago | Monthly |
| *C–2* | *Revista de Marina*<br>Casilla del Correo 976, Valparaiso | Monthly<br>Per year $15.00 |

## COLOMBIA

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| *Co–1* | *Memorial del Estado Mayor del Ejercito de Colombia*<br>Jefe del Departamento de Historia del<br>Estado Mayor-General<br>Bogota | Bimonthly<br>Per year $0 50 oro |

## DENMARK

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| *D–0.5* | *Dansk Artilleri-Tidsskrift*<br>Copenhagen | Bimonthly<br>Per year 5 kr |
| *D–1* | *Militært Tidsskrift*<br>Copenhagen | Semimonthly<br>Per year 8 kr |

## DOMINICAN REPUBLIC

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|---|---|---|
| *DR–1* | *El Porvenir Militar*<br>Salome Urena No. 8<br>Santo Domingo | Monthly |

## FRANCE

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|---|---|---|
| *F–1* | *Archives Militaires, Les*<br>Librairie Militaire Berger-Levrault<br>5-7 Rue des Beaux-Arts, Paris | Quarterly<br>Per year 14 fr |
| *F–2* | *France Militaire, La*<br>10 Rue Danton, Paris | Daily<br>Per year 32 fr |
| *F–3* | *Génie Civil, Le*<br>6 Rue de la Chaussée d'Antin, Paris | Weekly<br>Per year 45 fr |
| *F–4* | *Journal des Sciences Militaires*<br>30 Rue Dauphine, Paris | Weekly<br>Per year 40 fr |
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| *F-9* | *Monde Militaire, Le*<br>6 Rue de la Chaise, Paris | Fortnightly<br>Per year 6 fr |
| *F-10* | *Revue d'Artillerie*<br>5 Rue des Beaux-Arts, Paris | Monthly<br>Per year 22 fr |
| *F-11* | *Revue de Cavalerie*<br>5 Rue des Beaux-Arts, Paris | Monthly, ex. Aug.<br>Per year 27 fr |
| *F-12* | *Revue du Génie Militaire*<br>5 Rue des Beaux-Arts, Paris | Monthly<br>Per year 27 fr |
| *F-13* | *Revue d'Infanterie, La*<br>10 Rue Danton, Paris | Monthly<br>Per year 25 fr |
| *F-14* | *Revue Maritime*<br>30 Rue et Passage Dauphine, Paris | Monthly<br>Per year 36 fr |
| *F-15* | *Revue Militaire des Armées Etrangères*<br>Librairie Chapelot<br>30 Rue et Passage Dauphine, Paris | Monthly<br>Per year 15 fr |
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## GERMANY

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| *G-1* | *Artilleristische Monatshefte*<br>Bernburgerstr. 24-25 Berlin, S. W. 11 | Monthly<br>Per year 27 M |
| *G-2* | *Eisen-Zeitung*<br>Otto Elsner, Verlaggesellschaft m.b.H.,<br>Oranienstrasse 140, Berlin, S. 42. | Weekly<br>Per year 12 M |
| *G-3* | *Ingenieur, Der*<br>Verlag Buchdruckerei F. Posekel,<br>Gneisenaustrasse 67, Berlin S. 61 | Semimonthly<br>Per year 16 M |
| *G-3.5* | *Kriegstechnische Zeitschrift*<br>E. S. Mittler & Sohn<br>Königliche Hofbuchhandlung,<br>Kochstrasse, 68-71, Berlin, S. W. | 10 nos. per yr.<br>Per year 10 M. |
| *G-4* | *Marine Rundschau*<br>Koch Strasse, 68-71, Berlin, S.W. | Monthly<br>Per year 10 M |
| *G-5* | *Militaer Wochenblatt*<br>*With monthly Supplement*<br>Koch Strasse, 68, Berlin, S.W., 12 | 3 times a week<br>Per year 18 M |
| *G-6* | *Schiffbau*<br>Neuenburgerstr. 8, Berlin, S.W., 68 | Semimonthly<br>Per year 20 M |
| *G-8* | *Ueberall*<br>Boll und Pickardt<br>Berlin, N.W. 7 | Monthly<br>Per year 15.6 M |
| *G-9* | *Zeitschrift fuer das Gesamte Schiess- und Sprengstoffwesen*<br>J. F. Lehmann, Paul Heysestr. 26,<br>Munich, S.W. 2 | Semimonthly<br>Per year 26 M |

## HOLLAND

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| *H-1* | *Orgaan der Vereeniging ter beoefening van de Krijgswetenschap*<br>Z. O. Buitensingel 224<br>The Hague | <br>Six nos. per yr.<br>Per year 4 florins |
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| *I-1* | *Lista Navale Italiana*<br>Officina Poligrafica Italiana, Rome | Quarterly<br>Per year 15 L |
| *I-2* | *Rendiconti delle Esperienze e Degli Studi Eseguiti Nello Stabilimento di Esperienze e Costruzioni Aeronautiche del Genio*<br>Viale Giulio Cesare N. 2, Rome | <br>Occasional<br>Per year 13.50 L |
| *I-3* | *Rivista di Artiglieria e Genio*<br>Tipografia Enrico Voghera<br>Via Astalli 15, Rome | Monthly, ex. July<br>Per year 20 L |
| *I-4* | *Rivista Marittima*<br>Officina Poligrafica Italiana<br>Rome | Monthly<br>Per year 25 L |

## MEXICO

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| *M-1* | *Boletin de Ingenieros*<br>War Dept., Mexico City | Monthly |
| *M-2* | *Revista del Ejercito y Marina*<br>Departamento de Estado Mayor<br>City of Mexico | Monthly |

## NORWAY

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| *N-1* | *Norsk Artilleri-Tidsskrift*<br>Christiania | Bimonthly<br>Per year 6 kr |
| *N-2* | *Norsk Militært Tidsskrift*<br>Christiania | Monthly<br>Per year 8 kr |

## PERU

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| *Pe-1* | *Boletin del Ministerio de Guerra y Marina*<br>Apartado de Correo No. 91, Lima | Fortnightly |

## PORTUGAL

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| *Po-1* | *Anais do Club Militar Naval*<br>43 Rua do Carmo, Lisbon | Monthly<br>Per year 4$200 |
| *Po-2* | *Revista de Artilharia*<br>Rua do Carmo, 43, 2°., Direito, Lisbon | Monthly<br>Per year 3$000 rs |
| *Po-3* | *Revista de Engenharia Militar*<br>27 Rua Nova do Almada, Lisbon | Monthly<br>Per year 3$600 rs |
| *Po-4* | *Revista Militar*<br>Largo da Annunciada, 9, Lisbon | Monthly<br>Per year 3$000 rs |

## RUSSIA

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| *R-1* | *Imperial Nicholai War Academy Recorder, The*<br>St. Petersburg | Monthly<br>Per year 6 rubles |

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| *R–2* | *News of the Officers' Artillery School* | Monthly |
| | Zarskoye Selo | Per year 10 rubles |

## SPAIN

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| *Sp–1* | *Informacion Militar del Extranjero* | Monthly |
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| | Madrid | |
| *Sp–2* | *Memorial de Artilleria* | Monthly |
| | Museo de Artilleria, Madrid | Per year 18 ps |
| *Sp–3* | *Revista Cientifico-Militar* | Semimonthly |
| | *Guerra Europea, La* | Weekly |
| | Paseo de San Juan, 201, Barcelona | Per year 40 ps |
| *Sp–4* | *Revista General de Marina* | Monthly |
| | Ministerio de Marina, Madrid | Per year 25 ps |

## SWEDEN

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| *Sn–1* | *Artilleri-Tidsskrift* | Bimonthly |
| | Artillerigarden, Stockholm | Per year 6 kr |
| *Sn–2* | *Svensk Kustartilleritidskrift* | Quarterly |
| | Karlskrona | Per year 6 kr |

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| | Frauenfeld | Monthly |
| | | Per year 5 fr |
| *Sd–4* | *Schweizerische Zeitschrift fuer Artillerie und Genie* | |
| | Frauenfeld | Monthly |
| | | Per year 8 fr |

## UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ITS COLONIES AND POSSESSIONS

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| *UK–1* | *Arms and Explosives* | Monthly |
| | Effingham House | Per year 7s |
| | Arundel Street, Strand, London, W.C. | |
| *UK–3* | *Army Review, The* | Quarterly |
| | Wyman & Sons, Ltd. | Per copy 1s |
| | Fetter Lane, London, E. C. | |
| *UK–3.5* | *Australian Military Journal, The* | Quarterly |
| | Melbourne, Australia | Per copy 1s |
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| | Room 16, Trust Bldg. | Per year $2.50 |
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| *UK–6* | *Electrician, The* | Weekly |
| | 1, 2 and 3, Salisbury Court, Fleet Street | Per year 30s |
| | London | |
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| | 4, Ludgate Hill, London, E. C. | Per year £1 10s |

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| *US-3L* | *American Journal of International Law, The*<br>Baker, Voorhis & Co., 45 John St., N.Y. | Quarterly<br>Per year $5.00 |
| *US-4* | *American Journal of Mathematics*<br>Johns Hopkins Press<br>Baltimore, Md. | Quarterly<br>Per year $5.00 |
| *US-5* | *Arms and The Man*<br>1502 H Street, N.W., Washington, D. C. | Weekly<br>Per year $3.00 |
| *US-6* | *Army and Navy Journal*<br>20 Vesey Street, New York | Weekly<br>Per year $6.00 |
| *US-7* | *Army and Navy Register*<br>Washington, D. C. | Weekly<br>Per year $3.00 |
| *US-8* | *Bulletin of the American Geographical Society*<br>Broadway at 156th Street, New York City | Monthly<br>Per year $5.00 |
| *US-10* | *Bulletin of the American Mathematical Society*<br>501 West 116th Street, New York | Ten nos. per yr.<br>Per year $5.00 |
| *US-11* | *Bulletins and Circulars of the Bureau of Standards*<br>Department of Commerce and Labor<br>Washington, D. C. | |
| *US-12L* | *Bulletin of the Pan American Union*<br>Seventeenth and B Streets, N.W.<br>Washington, D. C. | Monthly<br>Per year $2.00 |
| *US-13* | *Bulletin of Iowa State College*<br>Ames, Iowa | Monthy |
| *US-14* | *Bulletin of the University of Illinois*<br>Urbana, Illinois | |
| *US-15* | *Bulletins, Circulars and Technical Papers*<br>*Bureau of Mines*<br>Department of the Interior<br>Washington, D. C. | Occasional<br>Free |
| *US-16L* | *Canal Record*<br>Ancon, Canal Zone, Isthmus of Panama | Weekly<br>Per copy 5c |
| *US-17.75 L* | *Colonial Wars*<br>9 Ashburton Place<br>Boston | Quarterly<br>Per year $3.00 |
| *US-18* | *Compressed Air Magazine*<br>Compressed Air Magazine Co.<br>Easton, Pa. | Monthly<br>Per year $1.50 |
| *US-19* | *Confederate Veteran*<br>Nashville, Tenn. | Monthly<br>Per year $1.00 |
| *US-20* | *Craftsman, The*<br>41 W. 34th Street, New York | Monthly<br>Per year $3.00 |
| *US-21* | *Electric Journal, The*<br>200 Ninth Street, Pittsburgh, Pa. | Monthly<br>Per year $1.50 |
| *US-22* | *Electrical Review and Western Electrician*<br>Heisen Building<br>608 South Dearborn Street, Chicago | Weekly<br>Per year $3.00 |

America invents a "Zeppelin-destroyer"—US-40.5L, March 27, 15.
An airship in the field—US-66L, March 27, 15.
A review of recent air-raids and what they have accomplished—US-66L, April 17, 15.
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Attack and defense against hostile aircraft by artillery in the field—UK-11, February, 15.
Anti-aeroplane guns in the field—UK-11, March, 15.
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| *US–45L* | *National Geographic Magazine, The*<br>Hubbard Memorial Hall<br>Washington, D. C. | Monthly<br>Per year $2.50 |
| *US–46* | *National Guard Magazine, The*<br>136-140 East Gay Street<br>Columbus, Ohio | Monthly<br>Per year $1.00 |
| *US–47* | *Navy, The*<br>Southern Building<br>Washington, D. C. | Monthly<br>Per year $2.00 |
| *US–47.5L* | *North American Review, The*<br>The North American Review Publishing Company<br>New York City | Monthly<br>Per year $4.00 |
| *US–48* | *Official Gazette of the United States Patent Office, The*<br>Supt. of Documents, Gov. Printing Office<br>Washington, D. C. | Weekly<br>Per year $5.00 |
| *US–48.5L* | *Outlook, The*<br>287 Fourth Ave., New York | Weekly<br>Per year $3.00 |
| *US–49* | *Pennsylvania Magazine of History and Biography*<br>Philadelphia, Pa. | Quarterly<br>Per year $3.00 |
| *US–50* | *Physical Review*<br>41 North Queen Street, Lancaster, Pa. | Monthly<br>Per year $6.00 |
| *US–51* | *Polytechnic, The*<br>Troy, N. Y. | 10 nos. per yr.<br>Per year $2.00 |
| *US–52* | *Popular Mechanics*<br>6 N. Michigan Boulevard, Chicago, Ill. | Monthly<br>Per year $1.50 |
| *US–54L* | *Proceedings of the American Institute of Electrical Engineers*<br>33 West 39th Street<br>New York | Monthly<br>Per year $10.00 |
| *US–55* | *Proceedings of the American Philosophical Society*<br>104 South Fifth Street, Philadelphia, Pa. | |
| *US–56* | *Proceedings of the American Society of Civil Engineers*<br>220 West 57th Street<br>New York | 10 nos. per year<br>Per year $8.00 |
| *US–57* | *Proceedings of The Engineers' Club of Philadelphia*<br>1317 Spruce Street<br>Philadelphia, Pa. | Quarterly<br>Per Vol. $2.00 |
| *US–58* | *Proceedings of The Engineers' Society of Western Pennsylvania*<br>2511 Oliver Building<br>Pittsburgh, Pa. | 10 nos. per year<br>Per year $5.00 |
| *US–59* | *Proceedings of the U. S. Naval Institute*<br>Annapolis, Md. | Bimonthly<br>Per year $3.00 |
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| *US–61* | *Reactions*<br>Goldschmidt Thermit Company<br>90 West Street, New York | Quarterly<br>Per year $0.25 |

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Field officers' courses at the Mounted Service School and abroad—US-39, January-April, 15.

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| | Christiania | Per year 6 kr |
| *N-2* | *Norsk Militært Tidsskrift* | Monthly |
| | Christiania | Per year 8 kr |

## PERU

| | | |
|---|---|---|
| *Pe-1* | *Boletin del Ministerio de Guerra y Marina* | Fortnightly |
| | Apartado de Correo No. 91, Lima | |

## PORTUGAL

| | | |
|---|---|---|
| *Po-1* | *Anais do Club Militar Naval* | Monthly |
| | 43 Rua do Carmo, Lisbon | Per year 4$200 |
| *Po-2* | *Revista de Artilharia* | Monthly |
| | Rua do Carmo, 43, 2°., Direito, Lisbon | Per year 3$000 rs |
| *Po-3* | *Revista de Engenharia Militar* | Monthly |
| | 27 Rua Nova do Almada, Lisbon | Per year 3$600 rs |
| *Po-4* | *Revista Militar* | Monthly |
| | Largo da Annunciada, 9, Lisbon | Per year 3$000 rs |

## RUSSIA

| | | |
|---|---|---|
| | *Imperial Nicholai War Academy Recorder, The* | Monthly |
| | St. Petersburg | Per year 6 rubles |

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| *R-2* | *News of the Officers' Artillery School* | Monthly |
| | Zarskoye Selo | Per year 10 rubles |

## SPAIN

| | | |
|---|---|---|
| *Sp-1* | *Informacion Militar del Extranjero* | Monthly |
| | Talleres del Deposito de la Guerra | |
| | Madrid | |
| *Sp-2* | *Memorial de Artilleria* | Monthly |
| | Museo de Artilleria, Madrid | Per year 18 ps |
| *Sp-3* | *Revista Cientifico-Militar* | Semimonthly |
| | *Guerra Europea, La* | Weekly |
| | Paseo de San Juan, 201, Barcelona | Per year 40 ps |
| *Sp-4* | *Revista General de Marina* | Monthly |
| | Ministerio de Marina, Madrid | Per year 25 ps |

## SWEDEN

| | | |
|---|---|---|
| *Sn-1* | *Artilleri-Tidsskrift* | Bimonthly |
| | Artillerigarden, Stockholm | Per year 6 kr |
| *Sn-2* | *Svensk Kustartilleritidskrift* | Quarterly |
| | Karlskrona | Per year 6 kr |

## SWITZERLAND

| | | |
|---|---|---|
| *Sd-1* | *Allgemeine Schweizerische Militarzeitung* | Weekly |
| | Benno Schwabe & Co., Basel | Per year 13 fr |
| *Sd-2* | *Revue Militaire Suisse* | Monthly |
| | Avenue Juste Olivier, Lausanne | Per year 15 fr |
| *Sd-3* | *Schweizerische Monatschrift fuer Offiziere Aller Waffen* | |
| | Frauenfeld | Monthly |
| | | Per year 5 fr |
| *Sd-4* | *Schweizerische Zeitschrift fuer Artillerie und Genie* | |
| | Frauenfeld | Monthly |
| | | Per year 8 fr |

## UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ITS COLONIES AND POSSESSIONS

| | | |
|---|---|---|
| *UK-1* | *Arms and Explosives* | Monthly |
| | Effingham House | Per year 7s |
| | Arundel Street, Strand, London, W.C. | |
| *UK-3* | *Army Review, The* | Quarterly |
| | Wyman & Sons, Ltd. | Per copy 1s |
| | Fetter Lane, London, E. C. | |
| *UK-3.5* | *Australian Military Journal, The* | Quarterly |
| | Melbourne, Australia | Per copy 1s |
| *UK-4* | *Canadian Military Gazette* | Semimonthly |
| | Room 16, Trust Bldg. | Per year $2.50 |
| | Ottawa, Canada | |
| *UK-6* | *Electrician, The* | Weekly |
| | 1, 2 and 3, Salisbury Court, Fleet Street | Per year 30s |
| | London | |
| *UK-7* | *Electrical Review* | Weekly |
| | 4, Ludgate Hill, London, E. C. | Per year £1 10s |

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|---|---|---|
| *UK–8* | *Engineer, The*<br>33 Norfolk Street, Strand<br>London, W.C. | Weekly<br>Per year £1 16s |
| *UK–9* | *Engineering*<br>35-36 Bedford Street, Strand<br>London, W.C. | Weekly<br>Per year £1 16s |
| *UK–10* | *Iron & Coal Trades Review, The*<br>165 Strand, London, W. C. | Weekly<br>Per year 27s |
| *UK–10.5* | *Journal of the Institution of Mechanical Engineers, The*<br>Storey's Gate, St. James Park<br>London, S. W. | Occasional<br>8 nos. per year |
| *UK–11* | *Journal of the Royal Artillery, The*<br>Woolwich | Monthly<br>Single copy 2s 6d |
| *UK–12* | *Journal and Proceedings, Royal Society N. S. W.*<br>5 Elizabeth St., North Sydney, N. S. W. | |
| *UK–13* | *Journal of the Royal United Service Institution*<br>Whitehall, London, S.W. | Quarterly<br>Per year 24s |
| *UK–14* | *Journal of the United Service Institution of India*<br>Simla, India | Quarterly<br>Per year Rs 8 |
| *UK–15* | *Junior Institution of Engineers, The*<br>39 Victoria St., Westminster, S.W.<br>London | Monthly<br>Single copy 1s |
| *UK–17* | *Page's Engineering Weekly*<br>22 Henrietta Street, Covent Garden<br>London, W. C. | Weekly<br>Per year £1 1s |
| *UK–18* | *Photographic Journal*<br>35 Russell Square, London | Occasional<br>Copies 1s each |
| *UK–19* | *Proceedings of the Institution of Civil Engineers*<br>Great George St., Westminster, London, S. W. | |
| *UK–21* | *Royal Engineers Journal, The*<br>Chatham | Monthly<br>Per year 15s |
| *UK–22* | *Transactions of the Canadian Institute*<br>58 Richmond Street, Toronto, Canada | |
| *UK–23* | *Transactions of the Canadian Society of Civil Engineers*<br>176 Mansfield Street<br>Montreal, Canada | |
| *UK–24* | *Transactions of the Institution of Naval Architects*<br>5 Adelphi Terrace, London, W. C. | |
| *UK–25* | *United Service Gazette*<br>Caxton House, 11 Gough Square,<br>Fleet Street, London, E. C. | Weekly<br>Per year £1 10s 6d |
| *UK–26* | *United Service Magazine*<br>31, Haymarket<br>London, S. W. | Monthly<br>Per year £1 1s |

UNITED STATES

| | | |
|---|---|---|
| *US–0.5* | *Aerial Age Weekly*<br>116 West 32nd Street, New York City | Weekly<br>Per year $4.00 |
| *US–1* | *Aeronautics*<br>250 West 54th Street, New York City | Semimonthly<br>Per year $3.00 |

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|---|---|---|
| *US-2L* | *American Historical Review, The*<br>The Macmillan Company<br>41 N. Queen Street, Lancaster, Pa., or<br>66 Fifth Avenue, New York City | Quarterly<br>Per year $4.00 |
| *US-3L* | *American Journal of International Law, The*<br>Baker, Voorhis & Co., 45 John St., N.Y. | Quarterly<br>Per year $5.00 |
| *US-4* | *American Journal of Mathematics*<br>Johns Hopkins Press<br>Baltimore, Md. | Quarterly<br>Per year $5.00 |
| *US-5* | *Arms and The Man*<br>1502 H Street, N.W., Washington, D. C. | Weekly<br>Per year $3.00 |
| *US-6* | *Army and Navy Journal*<br>20 Vesey Street, New York | Weekly<br>Per year $6.00 |
| *US-7* | *Army and Navy Register*<br>Washington, D. C. | Weekly<br>Per year $3.00 |
| *US-8* | *Bulletin of the American Geographical Society*<br>Broadway at 156th Street, New York City | Monthly<br>Per year $5.00 |
| *US-10* | *Bulletin of the American Mathematical Society*<br>501 West 116th Street, New York | Ten nos. per yr.<br>Per year $5.00 |
| *US-11* | *Bulletins and Circulars of the Bureau of Standards*<br>Department of Commerce and Labor<br>Washington, D. C. | |
| *US-12L* | *Bulletin of the Pan American Union*<br>Seventeenth and B Streets, N.W.<br>Washington, D. C. | Monthly<br>Per year $2.00 |
| *US-13* | *Bulletin of Iowa State College*<br>Ames, Iowa | Monthy |
| *US-14* | *Bulletin of the University of Illinois*<br>Urbana, Illinois | |
| *US-15* | *Bulletins, Circulars and Technical Papers*<br>*Bureau of Mines*<br>Department of the Interior<br>Washington, D. C. | Occasional<br>Free |
| *US-16L* | *Canal Record*<br>Ancon, Canal Zone, Isthmus of Panama | Weekly<br>Per copy 5c |
| *US-17.75 L* | *Colonial Wars*<br>9 Ashburton Place<br>Boston | Quarterly<br>Per year $3.00 |
| *US-18* | *Compressed Air Magazine*<br>Compressed Air Magazine Co.<br>Easton, Pa. | Monthly<br>Per year $1.50 |
| *US-19* | *Confederate Veteran*<br>Nashville, Tenn. | Monthly<br>Per year $1.00 |
| *US-20* | *Craftsman, The*<br>41 W. 34th Street, New York | Monthly<br>Per year $3.00 |
| *US-21* | *Electric Journal, The*<br>200 Ninth Street, Pittsburgh, Pa. | Monthly<br>Per year $1.50 |
| *US-22* | *Electrical Review and Western Electrician*<br>Heisen Building<br>608 South Dearborn Street, Chicago | Weekly<br>Per year $3.00 |

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|---|---|---|---|
| *US-43* | *Military Surgeon, The*<br>535 North Dearborn Street<br>Chicago, Illinois | Monthly | Per year $3.50 |
| *US-45L* | *National Geographic Magazine, The*<br>Hubbard Memorial Hall<br>Washington, D. C. | Monthly | Per year $2.50 |
| *US-46* | *National Guard Magazine, The*<br>136-140 East Gay Street<br>Columbus, Ohio | Monthly | Per year $1.00 |
| *US-47* | *Navy, The*<br>Southern Building<br>Washington, D. C. | Monthly | Per year $2.00 |
| *US-47.5L* | *North American Review, The*<br>The North American Review Publishing Company<br>New York City | Monthly | Per year $4.00 |
| *US-48* | *Official Gazette of the United States Patent Office, The*<br>Supt. of Documents, Gov. Printing Office<br>Washington, D. C. | Weekly | Per year $5.00 |
| *US-48.5L* | *Outlook, The*<br>287 Fourth Ave., New York | Weekly | Per year $3.00 |
| *US-49* | *Pennsylvania Magazine of History and Biography*<br>Philadelphia, Pa. | Quarterly | Per year $3.00 |
| *US-50* | *Physical Review*<br>41 North Queen Street, Lancaster, Pa. | Monthly | Per year $6.00 |
| *US-51* | *Polytechnic, The*<br>Troy, N. Y. | 10 nos. per yr. | Per year $2.00 |
| *US-52* | *Popular Mechanics*<br>6 N. Michigan Boulevard, Chicago, Ill. | Monthly | Per year $1.50 |
| *US-54L* | *Proceedings of the American Institute of Electrical Engineers*<br>33 West 39th Street<br>New York | Monthly | Per year $10.00 |
| *US-55* | *Proceedings of the American Philosophical Society*<br>104 South Fifth Street, Philadelphia, Pa. | | |
| *US-56* | *Proceedings of the American Society of Civil Engineers*<br>220 West 57th Street<br>New York | 10 nos. per year | Per year $8.00 |
| *US-57* | *Proceedings of The Engineers' Club of Philadelphia*<br>1317 Spruce Street<br>Philadelphia, Pa. | Quarterly | Per Vol. $2.00 |
| *US-58* | *Proceedings of The Engineers' Society of Western Pennsylvania*<br>2511 Oliver Building<br>Pittsburgh, Pa. | 10 nos. per year | Per year $5.00 |
| *US-59* | *Proceedings of the U. S. Naval Institute*<br>Annapolis, Md. | Bimonthly | Per year $3.00 |
| *US-60* | *Professional Memoirs*<br>Washington Barracks, D. C. | Bimonthly | Per year $3.00 |
| *US-61* | *Reactions*<br>Goldschmidt Thermit Company<br>90 West Street, New York | Quarterly | Per year $0.25 |

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|---|---|---|
| *US-23* | *Electricity and Engineering*<br>608 South Dearborn Street, Chicago, Ill. | Monthly<br>Per year $1.00 |
| *US-24* | *Engineering Magazine, The*<br>140-142 Nassau Street, New York | Monthly<br>Per year $3.00 |
| *US-25* | *Engineering News*<br>Tenth Ave. at 36th Street, New York | Weekly<br>Per year $5.00 |
| *US-27* | *Field Artillery Journal, The*<br>U. S. Field Artillery Association<br>1701 Pennsylvania Avenue, N.W.<br>Washington, D.C. | Quarterly<br>Per year $3.00 |
| *US-28* | *Flying and The Aero Club of America Bulletin*<br>297 Madison Ave., New York | Monthly<br>Per year $3.00 |
| *US-29* | *General Electric Review*<br>General Electric Company<br>Schenectady, New York | Monthly<br>Per year $2.00 |
| *US-30* | *Infantry Journal*<br>U. S. Infantry Association<br>814 Seventeenth Street, N.W<br>Washington, D. C. | Bimonthly<br>Per year $3.00 |
| *US-31L* | *Journal of American History, The*<br>3 West 43rd Street, New York | Quarterly<br>Per year $3.00 |
| *US-31.5* | *Journal of the Efficiency Society, Inc., The*<br>29 West 39th Street, New York City | Monthly<br>Per year $3.00 |
| *US-33* | *Journal of The American Society of Mechanical Engineers, The*<br>29 West 39th Street,<br>New York City | Monthly<br>Per year $3.00 |
| *US-34* | *Journal of the American Society of Naval Engineers*<br>Navy Department, Washington, D.C. | Quarterly<br>Per year $5.00 |
| *US-35* | *Journal of the Association of Engineering Societies*<br>3817 Olive Street,<br>St. Louis, Mo. | Monthly<br>Per year $3.00 |
| *US-36* | *Journal of the Franklin Institute*<br>15 South Seventh Street, Philadelphia, Pa. | Monthly<br>Per year $5.00 |
| *US-37* | *Journal of the Military Service Institution*<br>Governor's Island, New York | Bimonthly<br>Per year $3.00 |
| *US-38* | *Journal of the U. S. Artillery*<br>Fort Monroe, Virginia | Bimonthly<br>Per year $2.50 |
| *US-39* | *Journal of the U. S. Cavalry Association*<br>Fort Leavenworth, Kansas | Quarterly<br>Per year $2.50 |
| *US-40* | *Journal of the Western Society of Engineers*<br>1735 Monadnock Block<br>Chicago, Illinois | Monthly<br>ex. July and Aug.<br>Per year $3.00 |
| *US-41* | *Machinery*<br>49-55 Lafayette Street, New York | Monthly<br>Per year $2.50 |
| *US-42* | *Metal Industry, The*<br>99 John Street, New York | Monthly<br>Per year $1.00 |
| *US-43* | *Military Surgeon, The*<br>535 North Dearborn Street<br>Chicago, Illinois | Monthly<br>Per year $3.50 |

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The periodical in which an article cited is published, is indicated by a symbol following the title of the article. For an explanation of the symbols used, see the key in the front of this pamphlet. Following the symbol, appears the date of the issue of the periodical in which the article will be found.

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War experiences of an air scout. The patrol of the sky—US-65, January 2, 15.
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Air-bombs—D-0.5, November, 14.
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### BIOGRAPHY

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Lord Kitchener—D-1, November 1, 14.
General George H. Thomas—US-37, January-February, 15.

### CAVALRY

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The hydroplane in coast defense reconnaissance—US-38, Nov.-Dec., 14.
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A suggestion regarding powder charges for target practice, 1915—US-38, November-December 14.

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The battleship *New York*—US-47, December, 14.

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## ERRATA

1. References to "C-1, November 24," should be to *C-1, October,* except on page 16, on which that reference should be eliminated.
2. References to "DR-1, November 18," should be to *DR-1, June-Sept.*
3. References to "Sp-2, December 2," should be to *Sp-2, October.*
4. Reference to "M-2, December 2" on page 16 should be eliminated.